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# SECURING INSTALLATIONS AGAINST CAR-BOMB ATTACK



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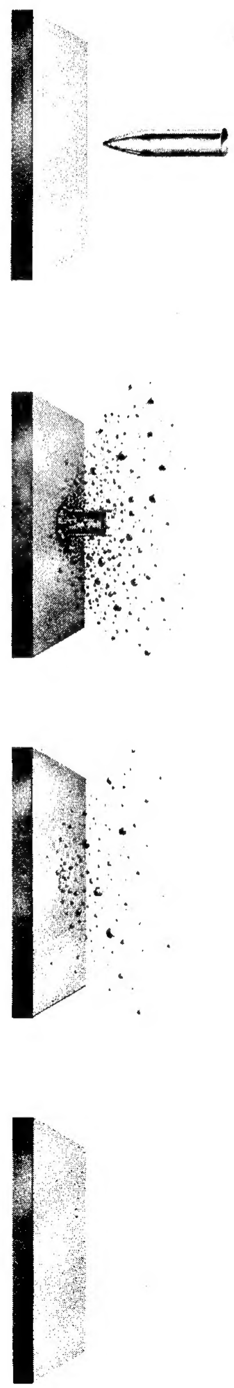

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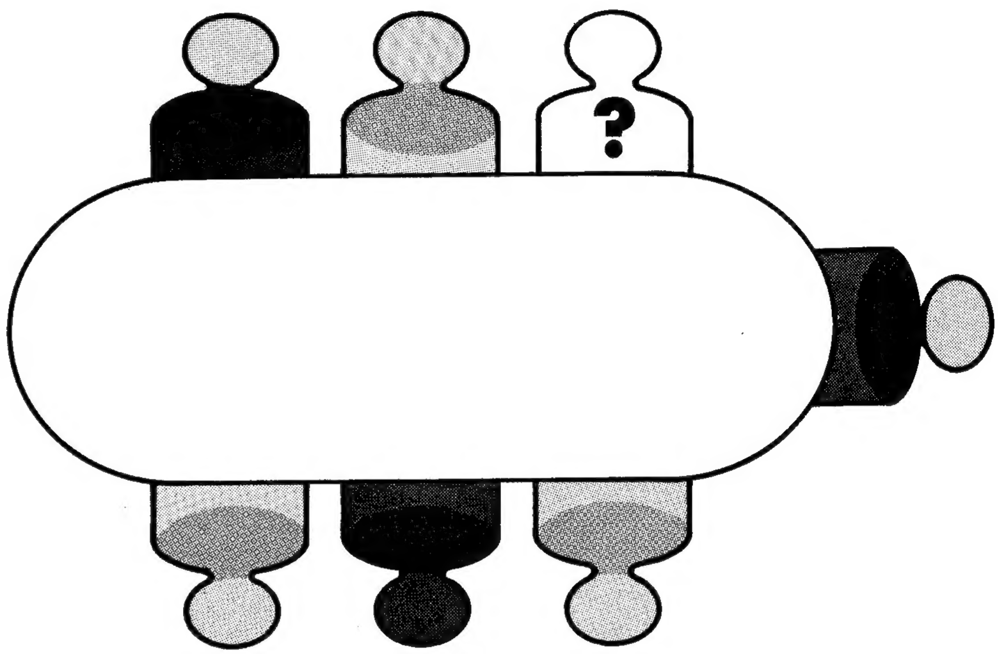
## FORMING A TEAM, BUT MISSING YOUR RIGHT HAND FOR SECURITY CONSIDERATIONS IN-PUT?

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## TABLE OF CONTENTS

## VOLUME 2: TECHNOLOGY APPLYING TO THE CAR-BOMB THREAT

## VEHICLE BARRIER ENGINEERING DESIGN

VOLUME 1

## VOLUME III

### PRODUCTS

#### BLAST WALLS



#### BLAST DOORS & VALVES



#### SHELTERS



#### VEHICLE BARRIERS

## DESIGN OF SYSTEMS ARCHITECTURE TO RESIST THE CAR-BOMB THREAT

### ENGINEERING OF DESIGN STRUCTURES TO RESIST BLAST



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### OTHER

# SIMPLICITY VS. RELIABILITY IN PHYSICAL SECURITY PRODUCTS

BY

GEORGE T. TALBOT, JR.

PREPARED FOR DEFENSE RESEARCH INSTITUTE
FOR PRESENTATION AT CONFERENCE
FRIDAY, 16 MAY 1986 AT ARLINGTON, VIRGINIA

PHYSICAL SECURITY SPEECH

IN PREPARING FOR THIS PRESENTATION I AM REMINDED OF THE PICTURE ON THE WALL IN MY FORMER OFFICE OF SECURITY ASSISTANCE PLANNING IN THE PENTAGON. IT PICTURED A SAD SACK TYPE DROOPY KIND OF GUY WITH OVERSIZE FATIGUES, A MUCH TOO LARGE CAP COVERING A LOOK OF ABSOLUTE INCREDULITY WITH THE UNDERLYING CAPTION; "REMEMBER! - WHATEVER YOU WRITE, WHATEVER YOU PLAN, WHATEVER YOU BUY, WHATEVER YOU IMPLEMENT, IT IS THIS MAN WHO HAS TO CARRY IT OUT." AND WHILE IT MAY NOT STRIKE YOU IMMEDIATELY THAT THIS MOPY FELLOW HAS ANY RELEVANCE TO EITHER YOU, YOUR PRODUCT OR TO YOUR PARTICULAR SECURITY ENVIRONMENT, PLEASE ALLOW ME TO DEVELOP A SCENARIO THAT SPEAKS TO THE TARGET RICH HIGH-THREAT INTERNATIONAL PHYSICAL SECURITY REQUIREMENT AND ITS RELEVANCE TO YOU, WHETHER YOU BE A MANUFACTURER, MARKETING MANAGER, OR SECURITY OFFICER.

RECENTLY, JOANNE OMANG IN THE WASHINGTON POST, QUOTING THE SECRETARY OF DEFENSE IN A SPEECH PREPARED FOR DELIVERY AT THE NATIONAL DEFENSE UNIVERSITY NOTED THAT TODAY AT LEAST ONE OUT OF EVERY FOUR COUNTRIES IS ENGAGED IN SOME FORM OF POLITICALLY DESTABILIZING LOW INTENSITY CONFLICT, MUCH OF IT TO INCLUDE VIOLENCE AND OFTEN INSURRECTION. FURTHER, AS THE CONDITIONS THAT BREED POLITICALLY DESTABILIZING VIOLENT ACTIVITY ARE RARELY LIMITED TO JUST ONE COUNTRY IN A REGION, THE PROBABILITY IS QUITE HIGH THAT HIGH-RISK PHYSICAL SECURITY THREAT SITUATIONS EXIST IN AT LEAST THREE/FOURTHS OF THE COUNTRIES OF THE WORLD IN GENERAL, AND IN NEARLY ALL OF THE DEVELOPING WORLD IN PARTICULAR.

GIVEN THEN THE GENERAL PARAMETERS OF THE HIGH-RISK THREAT ENVIRONMENT, ONE NEEDS TO STAND BACK AND EXAMINE THE SITUATION IN MORE THAN JUST PHYSICAL TERMS TO UNDERSTAND THE TRUE NATURE OF THE THREAT TO YOU AT THAT PARTICULAR PLACE AT THAT PARTICULAR TIME AND FURTHER TO EVALUATE THE SOCIAL, POLITICAL, ECONOMIC, TECHNOLOGICAL AND DEMOGRAPHIC FACTORS THAT WILL IMPACT DIRECTLY UPON YOUR ABILITY TO SOLVE THE PHYSICAL SECURITY PROBLEM. AGAIN, IN PREPARING TO EXPLAIN THE PHENOMENA OF THE VERY REAL LIMITATIONS INHERENT IN HIGH-TECH ORIENTED SECURITY PRODUCTS FOR THE DEVELOPING WORLD, AND TO MAKE THE CASE FOR CONSIDERATION OF SUCH SEEMINGLY ESOTERIC OR PERIPHERAL ISSUES AS DEMOGRAPHIC DATA, LET ME RELATE TO YOU A SET OF CIRCUMSTANCES SURROUNDING THE OUTFITTING OF AN ELITE PALACE GUARD IN AN AFRICAN COUNTRY.

SOME YEARS AGO WHEN I WAS IN INTERNATIONAL MARKETING FOR A U.K. BASED ELECTRO-OPTICAL FIRM, I HAD THE OCCASION TO SERVICE A CLIENT WHO HAD PREVIOUSLY SURFACED THE IDEA THROUGH GOVERNMENT CHANNELS THAT THEY WANTED TO EQUIP AN ELITE PALACE GUARD SWAT TEAM TYPE ORGANIZATION TO PROTECT THE PERSON AND INSTITUTION OF THE MONARCHY. ALTHOUGH THE THREAT AS PERCEIVED BY ME WAS MOST LIKELY TO COME FROM INTERNAL SOURCES ALREADY CLOSE TO THE LEVERS OF POWER AND FAMILIAR WITH WAYS TO CRIPPLE THE INSTITUTION FROM WITHIN, THE KING'S ADVISORS WERE CONVINCED THAT WHAT WAS NEEDED WAS AN ORGANIZATION MUCH LIKE YOU SEE IN THE MOVIES OR THE FBI'S HOSTAGE RESCUE TEAM WHICH COMES ON THE SCENE USUALLY WITH A DRAMATIC FLOURISH AND AFTER CONSIDERABLE DAMAGE HAS ALREADY BEEN

DONE AND THEN DEALS WITH THE PERPETRATOR IN AN OVERT RATHER VIOLENT MANNER. CONSEQUENTLY, IN AN ATTEMPT TO SATISFY THE ADVISOR'S AND OPERATOR'S APPETITES FOR THE LATEST IN DEFENSE EXOTICA FROM THE WEST WE OUTFITTED THE FORCE WITH NIGHT VISION GOGGLES AND INFRA-RED LASER GUIDED AIMING LIGHTS FOR THEIR INDIVIDUAL WEAPONS. FOR THOSE OF YOU NOT FAMILIAR WITH THIS PRODUCT, ITS EMPLOYMENT ENABLES THE OPERATOR TO TARGET WITH AN INVISIBLE LIGHT AND WITH PIN POINT ACCURACY, A POTENTIAL VICTIM UNBEKNOWNST TO ANYONE NOT SO EQUIPPED WITH COMPATIBLE NIGHT VISION GOGGLES. AS THE LASER GUIDED AIMING LIGHT IS BORESIGHTED AND ZEROED WITH THE PRIMARY WEAPON THE PIN-POINT IDENTIFICATION AND PLACEMENT OF THE LIGHT ON THE TARGET HAS THE EFFECT OF MARKING THE EXACT SPOT WHERE THE PROJECTILE WILL SOON STRIKE.

WHILE VERY SLICK IN AND OF ITSELF AND USED BY ALL ELITE COUNTER-TERRORIST STRIKE FORCES TODAY, THE ACQUISITION OF SUCH ACCURATE INSTRUMENTS OF CLOSE COMBAT IN THE HANDS OF ANY GROUP IN A LESS MATURE SOCIAL AND POLITICAL ENVIRONMENT CREATES NEARLY AS MANY HAZARDS AS IT PURPORTS TO SOLVE. INDEED, SHORTLY AFTER THIS EQUIPMENT WAS ACQUIRED AND TRAINING COMPLETED ON ITS EFFECTIVE UTILIZATION, OTHER ADVISORS TO THE KING, MORE PERCEPTIVE OF AND SENSITIVE TO THE PARTICULAR THREAT SCENARIO IMPACTING ON THIS SITUATION, HAD THE NIGHT VISION EQUIPMENT REMOVED FROM THE TACTICAL SQUAD, AS THE EXISTENCE OF WEAPONS SYSTEMS WITH SUCH POTENTIAL FOR LETHALITY IN THE HANDS OF ANY GROUP RAISES THE SPECTOR OF CREATING AN EVEN MORE SEVERE SOURCE OF INTERNAL DANGER AND IN ADDITION THEIR KNOWLEDGE OF AND CONTROL OF THIS EQUIPMENT

MARKS THEM AS A TARGET VULNERABLE TO EVEN MORE INTENSIVE POLITICAL MANIPULATION.

AN ISOLATED SITUATION YOU SAY? NOT SO! FOR EVERY OCCASION IN WHICH NEW HIGHLY EFFICIENT TECHNOLOGICALLY BASED INNOVATIONS ARE INTRODUCED INTO A LESS THAN TECHNOLOGICALLY OR POLITICALLY MATURE INFRASTRUCTURE, YOU RUN THE RISK OF CREATING A NEW SET OF ELITES WHO UPON MASTERING THE NEW SYSTEMS OR DEVICES SUPERCEDE THE ROLE MODEL ACCORDED TO THEM IN THAT SOCIETY AND NECESSARILY CONSTITUTE A THREAT TO ESTABLISHED ORDER IN A SITUATION THAT I THINK YOU'LL AGREE IS ALREADY RIVEN WITH ALL THE MAJOR ELEMENTS OF INSTABILITY. FURTHER, AS YOU EXECUTIVES AND MANAGERS WILL BE DEALING WITH THE UPPER REACHES OF THE CIVIL SERVANTS' CLASS YOU NECESSARILY WILL BE INTERACTING WITH THAT VERY THIN LAYER OF EDUCATED BUREAUCRATIC ELITES WHO ALONE COULD BE THREATENED BY THE INTRODUCTION OF NEW TECHNOLOGY WHICH REQUIRES FOR ITS EFFICIENT UTILIZATION THE TRAINING AND DEVELOPMENT OF A NEW CADRE OF TECHNOCRATS.

IF I CAN BE OF ASSISTANCE TO YOU IN ANY WAY, ABOVE ALL THE MOST IMPORTANT MESSAGE I CAN IMPART TO YOU TODAY IS TO MAXIMIZE THE FACTORS OF SIMPLICITY AND RELIABILITY IN BOTH INSTALLATION AND OPERATION WHEN ENGAGED IN DESIGN AND DEVELOPMENT OF SECURITY RELATED PRODUCTS FOR USE OUTSIDE OF THE WESTERN NATIONS. WHEN ONE CONSIDERS THE MANY LOCATIONS WHERE THREATS TO THE PHYSICAL SECURITY OF PROPERTY AND PERSON IS PERVASIVE, YOU WILL ALMOST INVARIABLY FIND AN EMERGING SOCIETY AND A DEVELOPING, POORER

NATION. WITH THE POSSIBLE EXCEPTION OF SPORADIC TERRORIST ATTACKS ON HIGH VISIBILITY SOFT TARGETS LIKE TOURISTS MILLING ABOUT AIRPORT WAITING LOUNGES OR IN THE SIDEWALK CAFE'S OF EUROPE'S CAPITOL CITIES, THE GREATEST THREATS TO PROPERTY EXIST IN THE DEVELOPING COUNTRIES WHERE SENSITIVE CAPITAL ASSETS AND BUILDINGS REPRESENTING SOFT U.S. COMMERCIAL AND POLITICAL INTERESTS ARE HIGH PROFILE TARGETS LARGELY VULNERABLE TO TERRORIST'S MISDEEDS. IT IS THIS TARGET, IN THE TOTALITY OF ITS ENVIRONMENT FOR WHICH WE MUST DESIGN OUR SECURITY PRODUCTS.

SURELY, WHEN YOU GENTLEMEN DESIGN PRODUCTS BY WHICH YOU HOPE TO SATISFY THE PHYSICAL SECURITY NEEDS OF AMERICA'S LARGEST CORPORATIONS AND ALSO PROVIDE PROTECTION FOR U.S. PERSONNEL AND AGENCIES OPERATING IN RADICALLY DESTABILIZED HIGH THREAT ENVIRONMENTS YOU DO NOT CONSIDER LITERACY OF THE OPERATING STAFF AS A DESIGN CRITERIA. YET IN THE LOCATIONS WHERE THOSE PRODUCTS EXPERIENCE THEIR GREATEST NEED AND UTILIZATION IS PRECISELY THOSE LOCATIONS WHERE A TECHNICALLY PROFICIENT AND RELIABLE WORK FORCE IS ALREADY IN VERY SHORT SUPPLY AND PRESENTLY COMPETED FOR AT OUTRAGEOUSLY INFLATED WAGE SCALES. FURTHER, FOLLOWING THE LABOR COST ISSUE IS THE MATTER OF LABOR INTENSIVE VS. CAPITAL INTENSIVE APPROACHES TO PROBLEM SOLVING IN THE PHYSICAL SECURITY ARENA. NORMALLY, WHEN SECURITY SYSTEMS ARE DESIGNED HERE IN THIS MOST TECHNOLOGICALLY ADVANCED SOCIETY, LABOR PRODUCTIVITY IS A PRIME CONSIDERATION GIVEN TO PRODUCT DEVELOPMENT. IN THE U.S. ONE OF THE MOST CRITICAL VARIABLES IN PROVIDING COST EFFECTIVE, RELIABLE SECURITY SYSTEMS IS THE COST OF EMPLOYING AN ADEQUATE QUALITY

WORK FORCE TO EITHER PROVIDE THE SECURITY OR MAN THE SYSTEMS WHICH ENHANCE SECURITY. TO THE EXTENT THAT SYSTEMS CAN BE SUBSTITUTED FOR COSTLY MAN-POWER WITH NO LOSS OR EVEN IMPROVEMENTS IN EFFICIENCY IS THE HALLMARK OF A SOPHISTICATED STATE-OF-THE-ART SYSTEM. HOWEVER, WHEN DESIGNING SYSTEMS FOR DEPLOYMENT IN THE DEVELOPING WORLD I AM REMINDED OF THE APPELATION OF A FORMER CHIEF DESIGN ENGINEER IN CHRYSLER'S SOUTH AMERICAN DIVISION YEARS AGO - WHEN ASKED BY ME WHY THEY DIDN'T MAKE A CAR WITH AN AUTOMATIC TRANSMISSION HE REPLIED - WHY DO YOU THINK - CHAUFFEURS ARE CHEAPER THAN THE AMORTIZED COST OF AN IMPORTED AUTO TRANSMISSION AND THEY PROVIDE STATUS, CONVENIENCE AND PERFORM OTHER TASKS AS WELL. IN DESIGNING SYSTEMS TO BE UTILIZED IN THE 3RD WORLD, SAVING JOB SPACES IS <u>NOT</u> ONE OF THE CRITERIA NORMALLY SOUGHT BY LEADERSHIP AS JOBS ARE HARD ENOUGH TO COME BY AT BEST FOR THE POPULACE - WHICH REMEMBER, IS WHAT IS TO BE PROTECTED AGAINST - AND BUREAUCRATS HAVE FEW ENOUGH OPPORTUNITIES TO REWARD FAITHFUL SUPPORTERS WITH PATRONAGE PLUMS - LIKE SECURITY FORCE EMPLOYEES.

AGAIN, WHEN ATTEMPTING TO DETERMINE A DESIGN APPROACH FOR A THIRD WORLD PHYSICAL SECURITY INSTALLATION A SITUATION SPECIFIC APPROACH TO THE PROBLEM WILL GENERALLY LEAD TO A MORE SATISFACTORY PRODUCT IN TERMS OF OPERATIONAL CAPABILITY AND RELIABILITY AND IT SHOULD LEAD TO LESS DISRUPTION OF THE WORK FORCE YIELDING GREATER CUSTOMER SATISFACTION AS WELL. WITHOUT GOING INTO A STATISTICAL LITANY DETAILING SOME OF THE MORE IMPORTANT DEMOGRAPHIC DATA RECOMMENDED TO CONSIDER IN PRODUCT

DEVELOPMENT ANALYSIS, I URGE YOU SIMPLY TO REFER TO THE STATISTICAL ABSTRACT OF THE WORLD BANK ANNUAL REPORT. HERE YOU WILL FIND ALL THE LATEST RELEVANT DATA REGARDING LITERACY, HEALTH AND STATE OF ECONOMIC DEVELOPMENT. I BELIEVE THAT SHOULD YOU DO THIS IN THE PREPARATORY PHASE OF AN OVERSEAS PHYSICAL SECURITY INSTALLATION PROJECT YOU WILL, LIKE ME, COME TO THE CONCLUSION THAT THE NATURE OF THE ~~THREAT~~ PROBLEMS TO BE OVERCOME IS CONSIDERABLY MORE THAN WHAT APPEARS OBVIOUS.

I WOULD BE NEGLIGENT IF I DID NOT MENTION POWER SOURCE. IS THERE ANYONE AMONG YOU WHO UPON CHECKING INTO THE FIRST CLASS BUSINESSMAN'S HOTEL IN THE DEVELOPING WORLD DID NOT DISCOVER A CANDLE IN THE DRESSER - AND THE NIGHTSTAND - AND IN THE SINK IN THE BATHROOM. WHAT DOES THAT TELL YOU? OF COURSE, THE ELECTRICITY SUPPLY IS SPORADIC AND IRREGULAR AT BEST. AH BUT YOU SAY WE CAN DEVELOP REDUNDANCIES INTO OUR SYSTEMS THAT OVERCOME THESE MINOR INCONVENIENCES. HA! SAY I, WHAT MAKES YOU THINK THAT IN SITUATIONS WHERE THE WHOLE SOCIETY DOESN'T WORK AND EVEN THE MOST ELEMENTAL FUNCTIONS OF GOVERNMENT ARE NON-EXISTENT THAT YOU CAN PROVIDE SAFETY AND RELIABILITY IN A MOST STRESSFUL ENVIRONMENT, WITH AN IMPORTED PRODUCT?

WHICH BRINGS ME TO ANOTHER SUBJECT, EASE OF MAINTENANCE AND REPAIR. GIVEN THE PREVIOUSLY MENTIONED VARIABLES ALL ASSOCIATED WITH UNEVEN SOCIETAL DEVELOPMENT, YOU CERTAINLY MUST BE AWARE OF WHAT KIND OF PROBLEMS ARE ENGENDERED WHEN A STATE-OF-THE-ART SECURITY SYSTEM, INSTALLED IN SOME REMOTE COUNTRY DEVELOPS A TINY

GLITCH. IF YOU HAVE TO FLY A REPAIR MAN IN FROM OHIO OR EVEN WESTERN EUROPE AND THERE ARE ONLY THREE FLIGHTS IN AND OUT OF THE COUNTRY - WHICH IS COMMON - IN A WEEK, YOU'VE GOT A REAL PROBLEM. IF THE PRODUCT WAS INSTALLED WITH A MAINTENANCE AND REPAIR GUARANTEE FOR THE FIRST YEAR OR TWO AND IT WAS NOT DESIGNED TO WITHSTAND THE DEPREDATIONS OF SAND AS FINE AS TALCUM POWDER, OR ELECTRICAL POWER SURGES OR GOATS NIBBLING AT THE INSULATION AROUND THE CABLES THEN YOU CAN WELL EXPEND THE ENTIRE PROFIT ON THE PROJECT IN TWO OR THREE EMERGENCY CALLS TO THAT COUNTRY. STATE-OF-THE-ART TECHNOLOGY TENDS TO BREED STATE-OF-THE-ART HEADACHES AND FIRST CLASS PROBLEMS WHEN BROKEN.

WHILE I'VE SPOKEN AT SOME LENGTH ABOUT WHAT NOT TO DO AND HOW TO EVALUATE THE TOTALITY OF THE THREAT ENVIRONMENT, WHAT YOU ASK ARE MY PRESCRIPTIONS FOR PROVISION OF RELIABLE SECURITY SYSTEMS? A FAIR QUESTION AND ONE I WILL ATTEMPT TO ADDRESS. FIRST, A SECURITY SYSTEM TO BE EMPLOYED IN A RELATIVELY UNDERDEVELOPED SOCIAL AND TECHNOLOGICAL ENVIRONMENT SHOULD BE LIKE DESIGNER CLOTHES - MAKE A STATEMENT - AN UNAMBIGUOUS PHYSICAL STATEMENT - THAT STATES THAT UNAUTHORIZED TRESPASS WILL INEXORABLY RESULT IN SEVERE BODILY HARM. IMMEDIATELY I THINK OF THE NEWER FORMS OF PERIMETER FENCING UTILIZING EXOTIC SPRING HARDENED METALS, ERECTED UNDER TENSION, IMPERVIOUS TO PENETRATION BY SURREPTITIOUS ENTRY. THESE FENCE MATERIALS FEATURE RAZOR BARBED ANGLED TIPS STAGGERED AT IRREGULAR INTERVALS AND THE STATEMENT THEY MAKE IS UNMISTAKABLE - YOU WILL BE SERIOUSLY HURT IF YOU ATTEMPT UNAUTHORIZED TRESPASS OF THIS BARRIER AND SHOULD

YOU ATTEMPT TO BREECH THIS SYSTEM BY ARMED FORCE YOU WILL SURELY HAVE CAUSED A RESPONSE BY A SECURITY FORCE BEFORE YOU CAN COMPLETE PENETRATION. FOR VEHICLES, I HAVE SEEN A SYSTEM EFFECTIVE AGAINST AUTOMOBILES AND TRUCKS AS AGAINST ARMORED VEHICLES AND IT'S SIMPLICITY DEFIES DEFEAT. IN DESIGN SOPHISTICATION, IT WAS STATE-OF-ART AROUND THE 12TH CENTURY - IT'S CALLED A MOAT. A DEEP, WIDE, ABYSS, PASSAGE OVER WHICH IS ACCOMPLISHED BY THE HAND ACTIVATION OF A MECHANICAL LEVER, POWER TO WHICH IS SUPPLIED BY A SELF-CONTAINED DIESEL OPERATED GENERATOR. THE PLATFORM IS MAINTAINED CONSTANTLY IN THE OPEN POSITION AND PASSAGE IS NEGOTIATED BY RECEIVING PERMISSION FROM GUARDS ON THE OPPOSITE SIDE ONLY AFTER WHICH IS THE PLATFORM SLID INTO PLACE. BY THE WAY, THIS DEVICE HAS A FEATURE WHICH ALLOWS THE OPERATOR TO CHANGE THEIR MIND AT ANY POINT DURING FINAL APPROACH OF THE VEHICLE - THE PLATFORM CAN BE REMOVED WHILE THE VEHICLE IS STILL ON IT CAUSING CERTAIN IRREPARABLE HARM TO THE VEHICLE AND ITS OCCUPANTS.

OBVIOUSLY WHERE EVER POSSIBLE YOU WANT TO CONSTRUCT FORMIDABLE PHYSICAL BARRIERS TO ENTRY AS FAR FORWARD OF THE ASSET TO BE PROTECTED AS POSSIBLE. AND OF COURSE WHERE THE SITUATION PERMITS, A REDUNDANT SYSTEM OF SECURITY CHECKS. HOWEVER, SOME INSTALLATIONS WE DESIRE TO PROTECT AND WHICH TODAY ARE PARTICULARLY VULNERABLE TO TERRORIST ATTACK ARE THOSE BUILDINGS THAT WERE BUILT IN A MORE SERENE TIME. FOR SOME ACTIVITIES WHERE RELOCATION IS POSSIBLE, I BELIEVE THE PRUDENT THING TO DO, IF THE ECONOMICS OF ONE'S OPERATIONS THERE JUSTIFY MAINTENANCE OF A

PRESENCE, IS TO MOVE THE ACTIVITY TO ANOTHER FACILITY WHERE SAFETY AND SECURITY COULD BE DESIGNED IN AT THE OUTSET. FOR SOME ACTIVITIES - AND IN MY VIEW EMBASSIES ARE PRIME EXAMPLES OF THIS - NORMAL BUSINESS JUST CANNOT BE CONDUCTED IF THE CENTRAL FACILITY WHERE THIS ACTIVITY IS TO BE CONDUCTED IS REMOVED A CONSIDERABLE DISTANCE FROM WHERE THE OTHER PLAYERS ARE SITUATED. AS DIPLOMACY IS AN INTENSELY PERSONAL AND LABOR INTENSIVE UNDERTAKING AS WELL AS BEING OF VITAL IMPORTANCE TO THE WELL BEING OF OUR NATION IT DOES NOT MAKE SENSE TO ME TO LET SECURITY CONSIDERATIONS TOTALLY DOMINATE THE CIRCUMSTANCES BY WHICH DIPLOMATIC ACTIVITY IS TO BE UNDERTAKEN. AND WHILE ADJUSTMENTS TO PRESENT ARRANGEMENTS WILL HAVE TO BE MADE IN BOTH THE LONG AND SHORT TERM, IT IS MY VIEW THAT IT IS PREFERABLE TO HAVE A HARD AND EVEN GROTESQUE LOOKING SECURITY APPARATUS SUPERIMPOSED OVER PRESENT SYSTEMS, THE JUSTIFICATION FOR WHICH IS READILY UNDERSTOOD, IN THE SHORT RUN THAN TO REMOVE THE ACTIVITY OR FUNCTION TO A SAFER MORE REMOTE LOCATION IMPACTING NEGATIVELY IN THE LONG RUN ON ONE'S ABILITY TO ACCOMPLISH THE BASIC MISSION - EVEN IF ONE IS SAFE IN SO ATTEMPTING IT.

IN CONCLUSION, I AM AWARE THAT I DID NOT PRESENT ANY NEW OR STARTLING INFORMATION TO YOU. IT MAY SOUND LIKE COMMON SENSE TO MANY OF YOU AND MANY OF YOU MAY NOT EVEN BELIEVE THAT THE "SIMPLE IS BETTER" APPROACH REALLY APPLIES TO YOUR PRODUCT LINE OR YOUR THEORIES ON THE SAFEGUARDING OF ASSETS AND INSTALLATIONS. TO THAT I CAN ONLY REPLY THAT AFTER HAVING SPENT AN ENTIRE ADULTHOOD IN THE DEVELOPING WORLD, WHOSE SOCIAL, CULTURAL, AND POLITICAL

TRADITIONS ARE WIDELY DIVERGENT FROM AND AT VARIANCE WITH OUR OWN SYSTEMS, THAT FEW IMPORTS FROM THE WEST - SAVE BLUE JEANS AND "ROCK-AND-ROLL MUSIC" - HAVE EVER BEEN SUCCESSFULLY INCORPORATED INTO DAILY LIFE STYLE PATTERNS OF THE THIRD WORLD WITHOUT SIGNIFICANT DISRUPTION. AS SYSTEMS AND INSTITUTIONS OF DEMOCRACY CANNOT BE EXPORTED, SO THE PRODUCTS OF EGALITARIAN, TECHNOLOGY BASED SOCIETIES CANNOT BE TRANSPLANTED WHOLE AND UNMODIFIED INTO ALIEN SOIL WITH ANYWHERE NEAR THE SAME LEVEL OF EXPECTED EFFECTIVENESS. I KNOW I HAVE PROVIDED NO HARD AND FAST ANSWERS, I ONLY HOPE THAT I HAVE STIMULATED A NEW APPROACH TO THE SOLUTION OF PROBLEMS OF PHYSICAL SECURITY IN THOSE AREAS OF THE WORLD WHERE THE PROBLEMS ARE GREATEST AND WHERE REQUIREMENTS WILL CONTINUE TO EXIST FOR YOU TO DISPLAY YOUR GREATEST ACHIEVEMENTS IN THE PHYSICAL PROTECTION OF LIFE DEPENDENT CAPITAL ASSETS.

THANK YOU!

# THE APPLICATION OF FRENCH 18TH CENTURY FORTRESS DESIGN PRINCIPLES TO DEFENSE AGAINST CAR BOMBS

Major Steven Myer

Jefferson J. Irvin

## 1.0 INTRODUCTION

Protecting a building or an installation against a car bomb threat involves many security considerations of a timeless nature: fortifying the target against the probable threat, establishing surveillance, creating obstacles to effective attack, and so on. There have been through the ages any number of security systems of varying success in meeting these considerations. The details of these security systems are applicable only to a particular threat, time and place, but the basic principles are immutable. This paper details one particular system, that of the French system of fortification used from the late seventeenth century through the early nineteenth century. From this analysis we will extract the underlying universal security principles em bodied in this venerable French system. We will conclude this paper with a checklist derived from these principles for the design of modern installation security.

Why analyze this particular system? The 17th-19th century fortress system evolved for two centuries against an essentially unchanging threat, that of the 24 pound smooth bore cannon. There were numerous wars testing the system and some of the best minds of the Age of Enlightenment were applied in the development and refinement of the system. The result of this intellectual trial and error was a compact (for cannon range was short) fortress whose layout, construction, and interior communications serve as an extremely useful model for the intelligent design of a security system protecting against a particular threat. A specific contemporary threat is the car bomb.

## 2.0 A GENERAL DESCRIPTION OF 18TH CENTURY FORTIFICATION

The eighteenth century fortification differs from the more familiar earlier castle. The high towers and exposed masonry walls of the castle became obsolete when accurate cannon were developed. The lower profile and thick, generally earth-filled walls of the 18th century fortress evolved from the new threat of bombardment. Assume you are attacker attempting a frontal assault against a fortress (Figure 1). You charge across 80 yards of bare ground (the "glacis") subjected to grazing fire from the infantry on the covered way and artillery fire from the ramparts. If you successfully storm the covered way, the jagged fortress

outline ensures that infantry and artillery on the ramparts can now hit you with enfilading fire along your attacking lines.

Your men have to either jump down twelve feet into the ditch or jam through narrow staircases (covered by defensive fires) into the ditch. The ditch is also enfiladed by fires from walls on the jagged fortress outline. At the opposite end of the ditch you have to climb a 30-foot wall to the ramparts on 40-foot ladders you somehow transported to the ditch. Once you scale the wall, you find you have have only taken the gun platform of an exterior fort detached from the main fortress. You are still subject to raking fire from elevated cannon, and you have yet another ditch to cross. Beyond these concerns, the defenders have prepared concealed routes for counterattack forces, which can assault you any time along the hazardous path to the innermost rampart.

In determining how the fortress design creates these difficulties for an attacker, we will analyze in turn three aspects of design: the design of the fortress profile, the design of the fortress plan (overhead) view, and the placement of the fortress inner communications. At the end of the discussion of each principle revealed by this security system, we will apply the principle to a modern design.

## 3.0 THE SECURITY SYSTEM PROFILE

A simplified fortress profile is shown in Figure 2. The dimensions of structural elements, the exterior dimensions (the profile outline), the vertical alignment of fortress elements in the profile, the lines of sight along the profile from both the defender and attacker viewpoints, and the sequential arrangements of fortress parts were all carefully thought out in the fortress design. We will discuss each of these points and their implications in turn.

### 3.1 The Eighteenth Century Profile

#### 3.1.1 Dimensions of Structural Elements in 18th Century Forts

The thickness of the fortress walls which supported the defending cannon and the thickness of the berms protecting the bodies of infantrymen from shot are carefully specified in the fortification design texts of the 18th and 19th centuries. Many studies were undertaken of the range, trajectory, accuracy, and destructive

impact of smooth bore cannon fire, and tabular data summarizing these studies were critical design aids (see Table 1 for period data concerning the threat, and see Table 2 in conjunction with Figure 2 to see how the data was applied). As beefing up the thickness and/or armoring of fortress walls involved no small expense, the effort applied to protect a wall was proportional to its exposure to enemy bombardment. Note the jagged fortress outline in Figure 1. The outward protruding points of the fortress (called the "salients") were subject to converging fires from enemy siege cannon, while the inward pointing fortress angles were relatively protected. The salients received special structural reinforcement. This could involve an increased frequency of exterior buttressing with structural ribs. A more expensive refinement would be to build the raised gun platforms on a series of tiered arched vaults on piers (rather than on compacted earth enclosed by escarpment retaining walls). The vaulted chambers next to the exposed walls could be filled with compacted earth. Note that this was a fairly resilient structure, not subject to catastrophic collapse. Where arched vaulting was used, the structural system was concealed by adding uniform courses of masonry on the exterior face subject to enemy view. This prevented targeting of critical structural elements.

### 3.1.2 18th Century Exterior Fortress Profile Dimensions

Knowledge of the enemy also dictated fortress profile dimensions. The minimum heights of the fortress walls and the minimum widths of the ditches were set to counter foot assault. Fortress walls had to be scaled with ladders of awkward dimensions, and ditches were too wide for any expedient bridging that could be safely carried across the cleared areas (swept by defensive cannon-fire) leading to the ditches.

The main point is that no fortresses were built with five foot high ramparts. The fortress obstacle dimensions forced the enemy into expensive (in time, money, and lives), deliberate breaching methods such as mining, or prolonged bombardment from inaccurate ranges.

### 3.1.3 Vertical Alignment of Fortress Elements

The vertical alignment of fortress elements was set so that rearward positions were higher than forward positions. This enabled cannon on the rearmost ramparts to fire over the heads of the outer defenses and thus provide support to the outer

defenses. This also allowed rear positions to fire directly on outer positions that were lost to enemy assault (note the rear exposure of the outer forts in Figure 1). The vertical alignment also shielded critical structural elements from enemy fire. The critical structural target was the base of the escarpment which supported the cannon on the rearmost ramparts. Collapse of this wall could deprive a large sector of the fortress from the commanding fires of long-range defensive cannon. Before, we noted that the width of the ditch prevented assault bridging. We also noted that the depth of the ditch was set to exceed a man's climbing ability. The depth was also set to shield the innermost rampart walls from enemy plunging cannon fires. Setting ditch dimensions required a careful balancing of design requirements.

### 3.1.4 Lines of Observation and Fire in the Fortress

First, view the fortress from the enemy position (see Figure 2). The glacis was sloped upwards towards the fortress. The enemy could see nothing of the pattern and dimension of the ditches which surrounded the fortress. He could only see the gun embrasures on the ramparts. The attacking commander was forced to perform daring, protracted reconnaissances in order to glean the fortress details necessary for the design of successful siege maneuvers.

Secondly, view the fortress from the position of an artillerist on the ramparts. The slope of the glacis is set to correspond exactly to the trajectory of the point blank fires of cannon on the rampart. The entire length of the path of a cannon shot rakes the open area. This provided a considerable advantage over plunging fires, which impacted on a single restricted area. In short, the lines of observation prevented the attacker from easily learning the fortress defenses, while simultaneously optimizing the effectiveness of fortress fires.

### 3.1.5 Sequencing of Fortress Obstacles

The sequence of obstacles presented to the besieger along the fortress profile greatly inhibited the successful attack. An attacker could scale the 30-foot high escarpment with 40-foot ladders, except for the problem of getting the ladders to the base of the wall. The large open area preceding the ditch, cleared to the limits of defensive small arms and cannon fire, made transport of cumbersome ladders a very risky operation.

In general terms, the rearward obstacle (the vertical face of the escarpment) was shielded from breach by the forward obstacle (the long, cleared area exposed to defensive fires).

3.1.6 Summary of Principles Concerning Fortress Profile Design

To summarize, the elements of the fortress profile of Figure 1 were sized according to the considerations given in Table 2. The development of this fortress profile yields the following basic principles:

1) The starting point for setting obstacle and main structure dimensions is understanding the means of delivery and destructive power of the prime enemy threat. Accurate data concerning the threat is required for design.

2) Concerning the chosen structural system which supports the critical target:
   - Structural protection is set by data concerning the threat.
   - The structural system should be disguised, to prevent the targeting of critical elements.
   - The structural system should be resilient, that is it should not be subject to catastrophic collapse after one successful attack.
   - The structural system should be reinforced in the areas most vulnerable to successful attack.

3) Concerning the dimensions of fortress obstacles, obstacle dimensions are set to exceed those which the enemy can rapidly breach. It follows that it is necessary to know well the breaching ability of an attacker.

4) The vertical placement of security elements should be set so that:
   - Security personnel closer to the attacker's target can observe and provide support to outer security.
   - Loss of an outer security position still leaves an attacker exposed to response from other security elements. No security position is concealed from the others.
   - The structure of outer security buildings or obstacles physically shields the structure of inner security buildings (or the target itself) from destruction.

5) The profile should be designed so that a prospective attacker seeking information about the security system must devote considerable time observing from a position exposed to surveillance and physical response by the defenders. The profile should be set to enhance the success of both the surveillance and the physical response. In other words, hide

obstacles and monitor closely the exposed vantage points from which the obstacles can be studied. Have and apply appropriate and visible means to for cibly prevent study.

6) Sequence obstacles in such a manner so that forward obstacles prevent breach of rearward obstacles.

## 3.2 Application to the Modern Profile

The above six principles can all be applied to the modern profile. The second principle has transparent modern application and will not be discussed further in any detail. The application of the other principles will all be discussed either in the section that follows, or in later sections where application overlaps with principles derived later.

### 3.2.1 Defining the Threat

As stated in the first profile principle, the starting point has to be a technical definition of the threat: its destructive power, and the means and path of its delivery. The threat addressed by this paper is the car bomb: a large explosion from a single point location. The discussion that follows concerning this threat is a non-technical overview, and seeks to apply general principles rather than define specific protective dimensions and distances needed to respond to the threat.

The ability of an explosive to breach (collapse or destroy) a target is affected by a number of factors. First is the power of the explosion, which is determined by the type of explosive and the amount of explosive. Second is the nature of the target itself, its structural material and its thickness. It is easier to collapse a brick wall than a reinforced concrete wall. It is easier to collapse a wall three feet thick than one which is six feet thick.

The third factor is distance of the explosion from the target. It seems obvious that it is better to be 200 feet from an exploding bomb than 50 feet from the bomb, but this factor requires further explanation. An explosion from a point source generates a pressure wave which travels outwards in an expanding sphere. The explosion releases a fixed amount of energy essentially instantaneously. It follows that as this fixed force of the explosion is spread over a progressively widening area, the damage done by the explosion diminishes rapidly the further the explosion is from the target. The important physical fact to comprehend is that an explosion behaves

like a wave. A wave can be reflected and a wave can be confined. If you stand 200 feet from an explosion in a reinforced concrete tunnel, the confinement of the explosive wave may make the destructive effect worse where you stand than if you stood 50 feet away from an explosion in an open area.

The fourth factor is thus the effect of confinement of the explosion. The military has a simple method of computing this effect. Figure 3 is a reproduction of an illustration in Field Manual 5-25 ("Explosives and Demolition"). The illustration shows that if an explosive is placed at the base of a target (the picture labelled "GROUND PLACED UNTAMPED") a large portion of the explosive wave is dissipated into the air or into the ground, and thus does not affect the target. This "base case" is given a factor of 3.6. If the explosive is raised up from the ground a distance equal to the thickness of the target, so that less explosive force is lost to the ground and more is directed at the target (see "ELEVATED UNTAMPED"), then the factor given is 1.8. These factors (3.6,1.8) are directly proportional to the amount of explosive needed to breach the target. The ratio of these two factors (1.8/3.6=0.5 the required explosives) shows that the elevated placement has double the effectiveness of the "base case" in terms of destroying the target. If you tamp the charges with sandbags (or earth), this also forces redirection into the target of previously dissipated energy, allowing a reduction of explosives necessary to cause collapse. The overall point of this discussion is that a security layout should be designed to prevent an explosion from taking place where the explosion is confined against the structure or area you want to protect. For example, cars should not have access to areas where reflection of an explosion from a wall would collapse a building, or rake a populated area.

Therefore, the destructive effect of an explosion is governed by the factors below:

- Type of explosive used
- Amount of explosive used
- Construction material in the target
- Thickness of the target
- Distance between point of detonation and the target
- Amount of confinement of the explosion

The designer of a security system has control in varying degrees over all the factors except the first. Simply put, an optimized design would cause vehicles to

explode at the furthest possible distance from the area to be protected, would confine the explosion at this distance (or reflect the explosion away from the protected area), and would ensure that the protected structure can safely absorb the uncontained portion of the worst case explosion.

### 3.2.1 Defining Minimum Obstacle Dimensions

The third profile principle states that obstacle dimensions must be designed so that the attacker cannot pass through the obstacle, or, if he does, the obstacle forces the attacker to expend so much time as to allow other measures to be assembled to prevent him from completing his attack successfully. Thus design requires knowledge about the attacker's vehicles, and his ability to destroy and clear, or bridge obstacles. U.S. military engineers are taught to design obstacles with dimensions based upon studies of the breaching capabilities of Soviet military vehicles. An effective obstacle against the 1970's generation of Soviet tank must be a ditch over 3 meters wide, a ramp with over a 45% slope, a vertical step over 1.5 meters high, or a stand of trees with diameters exceeding 20 centimeters spaced 3 to 5 meters apart. These dimensions are most likely sufficient to stop any vehicle likely to be used in a car bomb attack. These dimensions are small enough to allow for fairly simple construction, but also allow for fairly simple breach. It follows that a designer of a security system can largely control the distance of a car bomb explosion from a building by encircling the building with barriers impassable to vehicles. The problem of preventing car bomb explosions closer to the building is then one of suppressing the rapid breach of the encircling obstacle (by bridging or demolition) and controlling any passage points through the encircling obstacle. These problems will be discussed later.

### 3.2.3 Sequencing of Obstacles

The walls, ditches and open areas of a security system should be sequenced so that outer features shield inner features from observation and the effects of an explosion. To illustrate this principle, look at Figure 4, which shows two cases: first a wall followed by a ditch and then a ditch followed by a wall. In the first configuration of Figure 4:

- the wall shields the ditch from exterior view.

- the wall prevents the ditch from being rapidly bridged by some form of assault bridging (which could be simply a dump truck driving up and filling in the ditch).

- if a section of the wall is demolished, and a vehicle passes through the breach and explodes in the ditch, the dimensions of the ditch become critical in determining the direction of the main thrust of the explosion. See Figure 5. Note that if the leading wall is massive, the wall helps confine the explosion so that more force is directed towards the target. Therefore, if the wall and ditch necessarily must be very close to the target building, it becomes very important to design the ditch so that its innermost face confines the explosion, as in Figure 5(c). A large and expensive ditch is required in this instance.

In the second case of Figure 4:

- the wall shields the ditch from interior view. This makes it very important that the entire length of the ditch be kept under surveillance by security elements. Otherwise the ditch can be bridged (filled in) unobserved. These security elements are likely to be exposed.

- the ditch protects the front edge of the wall from explosive breach. Note that explosives placed in the ditch at the base of the wall do not blast simply through the thickness of the wall. The explosives must blast through the foundation of the wall and its earthen backfill also.

- An explosion in the ditch is confined and reflected by the ditch and wall in a direction away from the target building or area.

Therefore, concerning the two configurations shown in Figure 4:

- The combination of the two obstacles is much stronger than each obstacle alone. The advantage of placing obstacles in tandem is that the first obstacle prevents rapid breach of the second.

- Each of the two sequences shown in Figure 4 has its advantages and disadvantages. The choice of which configuration to use involves looking at the the proximity of the obstacles to the target, the ease of monitoring the obstacles, and expense of construction.

## 4.0 THE SECURITY SYSTEM PLAN VIEW

The "ease of monitoring the obstacles", referred to above, is largely set by the

layout of the security system in plan view. The 18th century layout in plan was successful in its time because it optimized the monitoring and protection of its obstacles. This layout relied on linear obstacles cleverly employed to be mutually reinforcing. We will discuss linear obstacles, and the principles governing their layout in turn.

### 4.1 The Eighteenth Century Plan View

#### 4.1.1 The Inherent Advantages of Linear Obstacles

Figure 6 shows a portion of a fortification overview over marked with defending artillery lines of fire. The lines of fire show that every ditch segment can be raked along its entire length by cannon and musket fire. A brave enemy could storm the open area preceding the ditch system, betting against the ability of the defending infantry and artillery to hit isolated, scattered, moving targets. Once into the ditches, the attacker had a problem. He stood directly in the preset line of fire of defending cannon.

This is the significant advantage of a linear obstacle, like a wall or ditch, as opposed to an area obstacle like a broad cleared area studded with isolated trees. The trees, if spaced widely enough to allow vehicle passage, may slow a driver down but will not reduce the area which must be observed or covered by fire. An area obstacle therefore buys time without aiding surveillance. A linear feature forces an attacker to stop and expend time before proceeding, thus also buying time for the defender. Unlike the case of the area obstacle, however, during the time gained the location of the attacker is fixed along a particular line of sight. A television camera trained along a tall wall that must be crossed is more effective as a survelliance measure than a camera that pans a large open area in regular sweeps.

#### 4.1.2 Linear Obstacles in Depth

Figure 6 shows that if an outer fortification was taken, there was a ditch behind that fortification, between the outer fort and the next rearward layer of forts. This ditch, like all ditches, was enfiladed by defensive fires. Because the outer forts were open to the rear and lower than the more inward forts, the outer gun platforms were themselves raked by rearward, commanding fires. The enemy thus received no relief when he took an outer fort; he remained in criss-crossing

zones of fire, and had additional linear obstacles to cross. The additional linear obstacle prevented the rapid assault of the inner fortress, and allowed the defender to react by transporting cannon and defenders from less threatened portions of the fortress, thus concentrating fires on the exposed attacker's position. The system was a rational series of linear obstacles in depth.

It is apparent that the more complex the fortress (the greater the depth of its maze of intersecting linear obstacles) the longer the fortress could hold out against a deliberate assault. The fortresses were not expected by their builders to be impregnable. They were designed to render impracticable the sudden successful assault, and force the enemy into expensive (in time and money) sustained bombardments and entrenchments. The tougher the entire nut was to crack, the more the enemy had to concentrate his effort on one particular part of that nut, and this gave the defenders the time and opportunity to concentrate against a single threat their necessarily restricted resources of cannon and men. The employment of linear obstacles in depth, though expensive to construct, allowed smaller and lesser equipped defending garrisons to extract a higher price from the enemy.

### 4.1.3 Protection of Forward "Blind Spots" By Rear Positions

Note from Figure 2 that a defender at the top of an escarpment stood some distance back from the edge of the escarpment, so that he could not see an enemy in the "blind spot" in the ditch at the base of his own position. The ditch at the base of his position was, however, a linear obstacle covered by fires from a more rearward defender (see Figure 6). Each ditch segment protected the base of forward positions and pointed at rearward protected positions. This freed the forward defender from worrying about his own defense, and allowed him to observe and defend a restricted area to his front. It is apparent that the more restricted a defender's area of observation, the more effective the surveillance.

### 4.1.4 Lengths of Linear Obstacles

The length of a ditch segment was matched to the maximum effective range of defending muskets sited to fire along the length of the ditch. The ends of ditches provided no respite from accurate fire from either cannon or musket. The destruction of a defender's cannon by enemy bombardment did not leave any portion of the ditch system defenseless.

### 4.1.5 Summary of Principles Concerning Fortress Plan View Design

To summarize, the fortress plan view yields the following basic principles:

1. A linear obstacle forces an attacker to expend time along a particular line of sight. Security forces should be placed to both observe and defend along this line of sight.

2. When linear obstacles are employed in depth, they should be sited so that when the first obstacle is breached the attacker must remain exposed to observation and action by the defender while he attempts to breach the second. The same conditions apply to the siting of a third linear obstacle, and so on.

3. The number of obstacles employed in depth is determined by the trade-off of cost of construction with the size and capabilities of the security force. In general, the more elaborate the physical obstacles, the smaller the size of the security force necessary.

4. The points from which the length of a linear obstacle is observed must in themselves be protected by observation from a rearward, more protected position. A guard who devotes himself to observing a particular access point or wall surface should have his unprotected flanks watched by a another, less exposed guard.

5. Linear obstacles should not be longer than the length that can be effectively observed and protected. Stated in another way, the spacing of security elements along a linear obstacle should not exceed the length that can be effectively observed and protected.

## 4.2 Application of the Modern Plan View

The above five principles can all be applied to the modern plan view. When protecting a relatively compact piece of real estate, however, many of the principles requiring an optimal siting of linear obstacles in depth may become difficult to apply. The advice supplied by the principles has to be tempered with space and aesthetic considerations.

### 4.2.1 Modern Linear Obstacles

The modern linear obstacle can be a structure obviously built for security

purposes, such as a wall, concrete ditch, or barbed wire fence. It can also be a more subtle feature of the grounds to be protected: a closely spaced stand of trees, a linear stretch of fountains, a walkway set into the ground surface with vertical sides 1.5 meters high, a line of concrete encased planters for short shrubs. The sole requirement is that the dimensions of the obstacle meet those required to stop a vehicle (see 3.2.2).

It is interesting to note that during the long stretch of peace between wars, various parts of the 18th century fortress were used for peaceful purposes: gardens were farmed in the ditches, the glacis was covered with orchards. When attack loomed, the trees on the glacis were cut down, leaving the root system to frustrate enemy entrenchment. There is historical precedent for dual purpose (peace and war) use of obstacles.

### 4.2.2 Intersecting Obstacles in Depth

At first glance, it seems that the employment of linear obstacles in the 18th century criss-crossing pattern, with security elements sighting along the line of each obstacle, is an impractical option from the modern viewpoint. When one considers the wide variety of landscaping features that are available to segment the grounds (see 4.2.1), the possibilities are more transparent. The bordering lines of the segmented grounds should point towards elevated positions of observation in the target building itself, or if possible, in outbuildings of the main building. This arrangement meets the requirements of the first and second plan view principles. In addition, the lines of sight along these segments from the elevated positions should be clear to the access and security points on the main perimeter of the grounds. In this way, the fourth plan view principle is satisfied.

### 4.2.3 Length of Linear Obstacles

The fifth plan view principle states that both sides of a linear obstacle should be observed along the full length of the obstacle. In modern terms this best translates in terms of lighting. The entire length of obstacles needs to be illumined at night.

## 5.0 THE INNER COMMUNICATIONS OF A SECURITY SYSTEM

Now we turn to discussing the dimensioning and layout of the inner fortress physical communications (gates, bridges, stairs) of the 18th century defensive system. How was the fortress designed to allow easy movement of friendly men and material between the various fortress components without making the attacker's job easier? Basically, the fortress designer carefully sized fortress passageways according to their required capacity, fitted gates and bridges with many redundant safeguards, and sited gates and bridges where they could receive maximum protection from the security force without enemy observation.

### 5.1 The Eighteenth Century Inner Fortress Communications

#### 5.1.1 Capacity of Lines of Communications

The bridges and gates which connected the various inner and outer fortress cannon platforms together (see Figure 7) all had a width and gentle gradient sufficient for the passage of artillery pieces and ammunition wagons. The width of stairs leading to the covered way was set to allow passage of the infantry which manned the covered way. These choices seem obvious. Less obvious is the fact that the stairs used for infantry passage were both too narrow and too steep for the passage of artillery. The covered way (used only by infantry) had no points accessible by artillery, except by the easily removed bridges. This meant that if the enemy by deliberate methods managed to capture part of the covered way and an outlying fortress element, he had no easy path for the transport of his artillery to the captured fort.

Thus where foot access was required, the access points were sized for foot access only. The few access points for wagons to the perimeter were easily removable.

#### 5.1.2 Redundant Safeguards at Access Points

Important fortress entranceways were designed with many redundant safeguards. The critical passageways through the main defense were called "posterns". The design of a postern, given in D. H. Mahan's 19th century text An Elementary Course in Permanent Fortification is described below.

"The most important postern is the one leading from the parade the plain behind the innermost ramparts to the main ditch....For greater security from surprise, its outlet is at least 6 feet above the bottom of the ditch, this difference of level being overcome by means of a temporary wooden ramp which receives an inclination of at least 1/6. Besides two strong doors at the two ends of the postern, there is a partition of masonry about midway between the two ends, which is pierced with a doorway of the same size as the doorways of the ends, and closed by a strong door which, as is the partition wall, is loop-holed for musketry.

In cases where the postern forms the main entrance to the work, an arched chamber is placed on one side of it, at the outlet, which serves as a guard-room for a few men, to secure the outlet from surprise. The wall between this chamber and the postern is loop-holed, so that a fire can be brought to bear on the doorway of the postern..."

Note the successive layering of features designed to seal the passageway. Removing the ramp makes storming or ramming the entrance difficult. The entrance, mid-point, and exit are sealed by doors and covered by fire.

The main point is that any one of these measures was a separate obstacle. The main access points were protected by a series of possibly redundant defensive features. These expensive precautions against surprise attack were taken because the fortress was like a turtle. Once you passed through the hard shell, the insides were soft.

5.1.3 The Siting of Access Points

The positions of the inner fortress passageways provide insight into how the careful siting of access points enhance the ability of the security force to protect them. Look at Figure 7. The following principles were used in siting the main gate and the bridges leading from the gate.

1. Forward passages were always covered by rearward defensive fires.

2. Passages were protected from enemy fire by forward positions.

3. Openings in the main perimeter were sited in the recessed

portions of the perimeter, allowing overlapping fires to rake the front of the opening. This placement also restricted the vantage points from where the enemy could observe or bombard the opening.

4. There were no openings on the sides of the detached forts. Openings were only to the rear. This prevented the loss of a fort from placing adjacent forts in danger of sudden assault through an open passageway.

5. Internal movement was masked from the enemy. The "covered way" was named because it covered the movement of defensive troops concentrating for counter-attack. Access to the covered way was likewise covered from observation by the fortress ditch system. The attacking enemy was forced to plan on defending troops descending upon his positions from any point of the fortress outline, with total surprise.

In a similar manner, the movement of artillery behind the raised gun platforms was hidden from the enemy, allowing the defender to reveal a surprise concentration of his cannon against specific enemy siege gun emplacements.

5.1.4 Summary of Principles Concerning Fortress Communications

To summarize, the study of inner fortress communications yields the following general principles.

1. Size communications to the need. Do not make openings through an obstacle wide enough for vehicle traffic when the opening only serves foot traffic.

2. Limit severely the number of entrances which serve vehicles, and design them to be easily removed or sealed.

3. Protect key entrances with many redundant safeguards.

4. Site entrances in recessed portions of the security perimeter. Observe and protect the entrance from these flanks, and from the rear.

5. Insure that breach of an outer entrance does not lead to free lateral movement within the protected area.

6. Cover the movement of security forces (to and from the entrances) from enemy observation or attack.

## 5.2 Application to Modern Security Area Movement

The above five principles can all be applied to modern security area movement.

### 5.2.1 Sizing Communications to the Need

The first principle from 5.1.4 is easily applied. Make entrances for pedestrians too narrow for vehicles. Make clearance into parking garages too small for trucks. One security measure related to package rather than car bombs is to make access to the interior of buildings via stairs only, and give security forces control of portable ramps for the passage of dolleys carrying large packages.

### 5.2.2 Limiting Number of Vehicle Entrances

The second principle is also simple to apply. In times of heightened danger, entrance of vehicles can be restricted to a single location, and the number of vehicles authorized routine entrance can be severely reduced.

### 5.2.3 Protecting Entrances With Redundant Safeguards

An entry point is designed to allow access to those authorized, deny access to those who are not, and provide time and protection to those who must judge how to meet the threat of someone attempting to force access. The major lesson taught by the third principle is not to put undue faith in a single security measure at a critical entrance. A series of seemingly redundant measures are demanded by the critical nature of entry points. Any initially controlled entry point should be followed by other measures: other controlled entrances, barriers that slow an attacking vehicle so time is bought to close these later entrances, etc.

One peripheral lesson that comes from study of the eighteenth century entranceway is the efficacy of the simple removable ramp. Assume that the entranceway into a compound involved driving one's vehicle down an incline which terminated short of a 1.5 meter vertical concrete step up to road level. The step could be erased (after inspection of the vehicle) by raising a simple ramp. The

double advantage of this "pit" is that an explosion in the pit is confined away from the target building.

5.2.4 Site Entrances in Perimeter Recesses

Siting an entrance in a recessed portion of the perimeter of a secured area gives the security force a number of advantages which should be exploited. First, the flanks of the area in front of the entrance can be manned by security forces, so that an attacker attempting to force his way through the entrance can be stopped by men to his sides and even rear. Secondly, the recessed entrance can only be observed from above, or from a very restricted area to the direct front of the entrance. A prospective attacker has few vantage points from which to study the entrance's defenses and processing procedures. If these vantage points are closely monitored by security forces and, if necessary, forcibly kept clear of dawdling observers (see the fifth profile principle), the entranceway will be kept significantly more secure.

5.2.5 Restricting Lateral Movement

The designer should plan for the case when, by deceit, demolition or whatever means, the attacker gets through an outer entrance or the outer perimeter linear obstacle (wall or ditch). If the attacker can move freely laterally, by leaving the road or staying on roads, he will have the ability to choose his own point of detonation and also will be much harder to stop.

To prevent lateral movement along the routine path of traffic, the interior road leading from the entrance should be lined with vehicular barriers. The segmenting of the compound as discussed in 4.2.2 would prevent lateral movement in the event of breach of an exterior compound wall or ditch.

5.2.6 Concealing of Security Force Movement

If the movements of a security force within the compound can be concealed, this has the advantageous effect of not only making an attacker's plan less than perfect, it also unsettles the confidence of the attacker and diverts some of his energy to protection against surprise. Movement of a security force could be concealed along the inner edges of intersecting linear obstacles discussed in 4.2.2.

## 6.0 SECURITY ENVIRONMENTS

Having determined these principles and applications for securing a building or installation against terrorist attack, we now turn to integrating these principles of design into different threat scenarios and security force capabilities. We define these three environments as follows:

Passive Environment: No active security force. Building is secured by design only. Examples: shopping centers, markets, public places without security forces.

Active Environment: A trained security force provides control measures, surveillance, search, obstacle activation, etc. They are armed only with personal weapons. Building structure, positive counter-measures, observation, and system reaction provide security.

Armed Environment: An armed military force provides the same resources of the active environment with the addition of large calibre weapons, armed convoys and patrols, intelligence systems and reaction forces.

The construction and layout of a building or installation should take into consideration not only the present environment and threat, but also the ability to move to a different environment based on a change to the threat. At Appendix A are checklists for each environment summarized from the principles and applications we have discussed.

## 7.0 CONCLUSION

We have illustrated the timeless principles of systems defense in the French fortifications of the 18th and 19th centuries and applied them in a general way to the problem of car bomb defense. Our aim has been to integrate the many considerations of the car bomb problem so that those involved in solutions to a specific problem can appreciate how a single solution fits into the whole. However, any solution involving isolated principles without integration into a total system is at risk for defeat in detail. It is critical that any building or installation design for original construction or security enhancement have a systems integrator that can

evaluate the threat, determine acceptable risk, and apply the principles we have discussed.

## TABLE 1

| CALIBER | MEAN RANGE (yds) | EFFECTIVE RANGE (yds) | DEPTH OF PENETRATION (ft) | PROTECTIVE BERM THICKNESS REQ'D (ft) |
|---|---|---|---|---|
| 24 and 16 lb. cannon | 1120-1340 | 445-670 | 13.5 | 20.0 |
| Musket Ball | 222-280 | 100-111 | 1.3 | 2-3.5 |

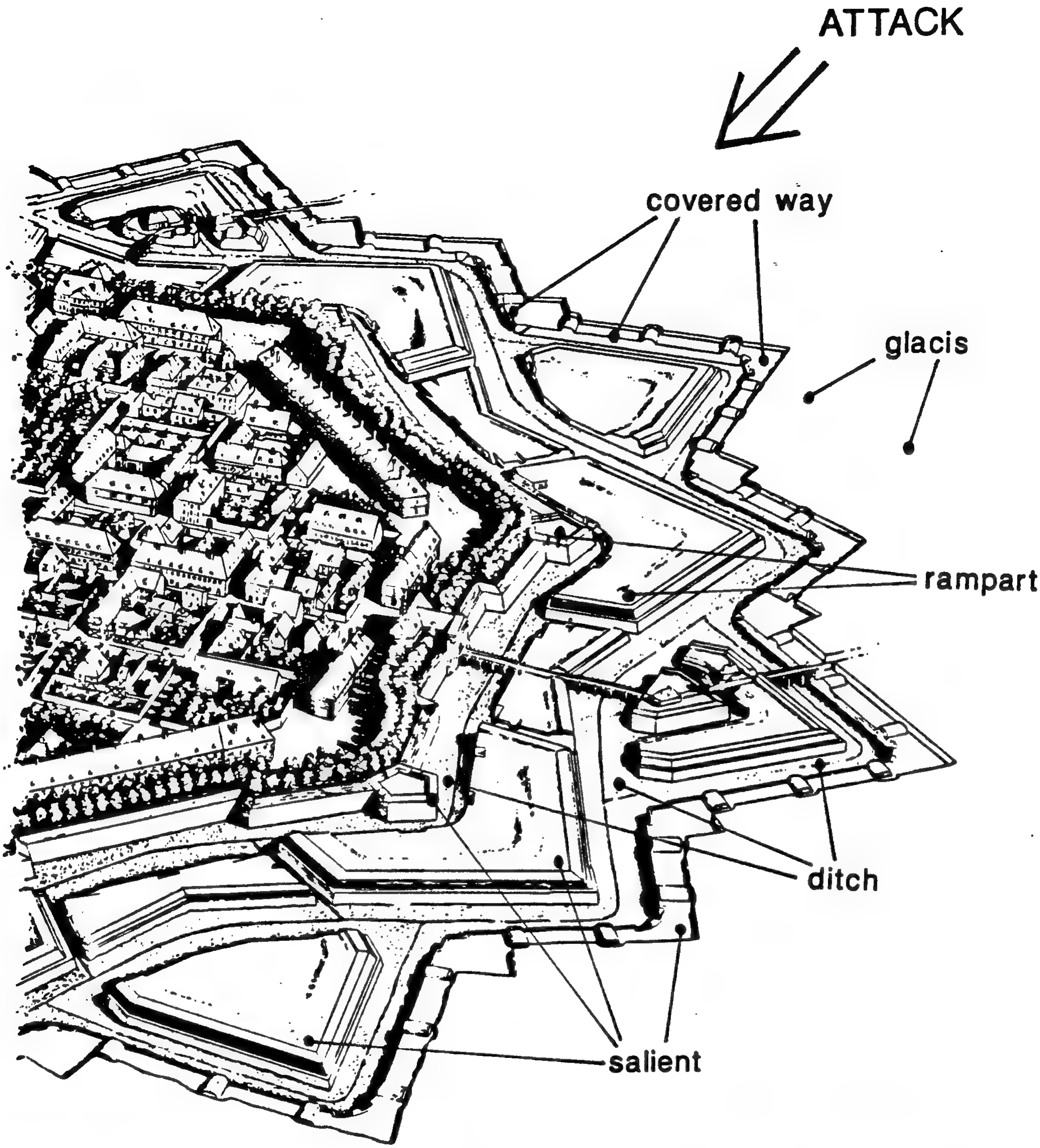
Note: Effective range for artillery was defined as the "point blank", the range at which the trajectory remains fairly flat. Land in front of cannon was cleared and sloped to conform to the cannon's point blank trajectory.

Data for this table was extracted from two tables in the 1817 text used at the United States Military Academy entitled: A Treatise on the Science of War and Fortification, translated from the original French by Cpt. John Michael O'Connor.

TABLE 2

| FEATURE FROM FIGURE 2 | PURPOSE | DIMENSION | CONSIDERATIONS GOVERNING CHOICE OF DIMENSION |
|---|---|---|---|
| Terreplain | Gun Platform | 44 ft wide | 14 ft: length of 24 lb cannon<br>12 ft: for recoil<br>18 ft: to allow two ammo carts to pass abreast |
| Banquette | Platform for Infantry | 4-5 ft wide | Allows two rows of musketeers, can step down onto terreplain to reload under cover. |
| Parapet | Provide cover to Infantry and Artillery | 19 ft thick, slope down "max 1/10 | 24 lb shot (enemy arty) has max penetration of 15 ft.; max downslope set by max depression of 24 lb cannon barrel. |
| Revetment (escarp-ment) | Repel enemy assault; absorb without failure enemy bombardment | 30 ft high, thick masonry | To scale a 30 ft high wall, attackers would have to carry 40 ft high ladders. |
| Ditch | Provide open area for fields of fire protecting the revetment | varies:"deeper than a man, wider than a tree", nor-mally 20-30 yds if dry,30-45 yds if waterfilled | Volume of ditch excavated is set by the amount of spoil needed to construct the fortress gun platforms. If ditch is narrow and deep, the revetment is masked from plunging fire; but if the revetment is breached, debris makes crossing the ditch easy. The wide and shallow ditch gives less protection to the revetment, but forces the enemy to trench across the ditch. |
| Counter-scarp | Provide cover for defensive counter-attack sorties, restrict access by enemy to ditch. | 12-15 ft high | High enough to make it difficult for assaulting troops to leap into the ditch. |
| Covered Way | Provide forward platform for defense infantry | 30 ft wide | Wide enough for troop move-ment, but not wide enough for attacking forces to use as a gun platform against the main ramparts. |
| Glacis | Provide open fields of fire for defending infantry firing from the covered way, and artillery firing from the ramparts. | 240 ft long " slope less than 1/10, and pleated. | The slope upwards is defined by max depression of cannon on the ramparts, and set equal to the slope of the parapet to en-hance grazing fire. Pleating effect occurs as planes of grazing fire from different bastions (forts at salients) intersect. |

The information to compile this table was taken from Chapter 4 of Fire and Stone, The Science of Fortress Warfare, by Christopher Duffy, publ. David and Charles, London, 1975; and from Chapter 1 of An Elementary Course of Permanent Fortifications, by D.H. Mahan, publ. John Wiley and Son, New York, 1874.




Reproduced from The History of Fortification, by Ian Hogg, St. Martin's Press Inc, New York, 1981

FIGURE 1

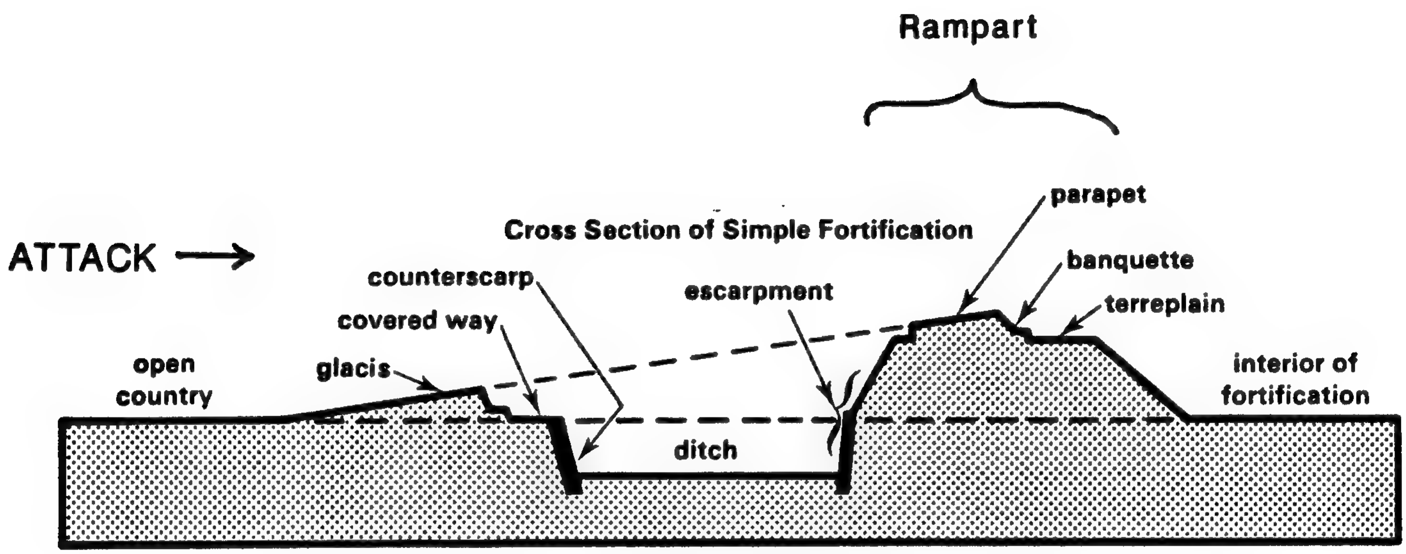

Rampart
parapet
Cross Section of Simple Fortification
ATTACK
banquette
counterscarp
escarpment
terreplain
covered way
open
country
glacis
interior of
fortification
ditch

FIGURE 2

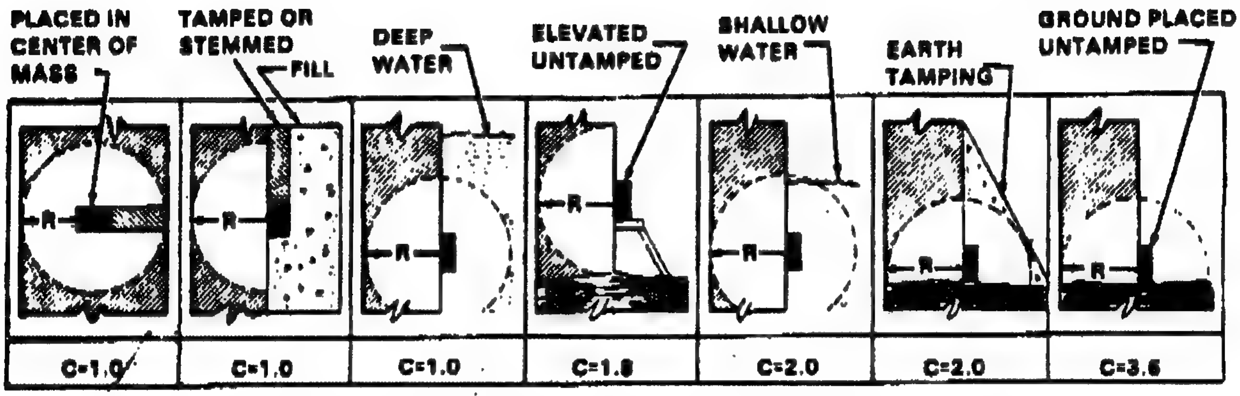
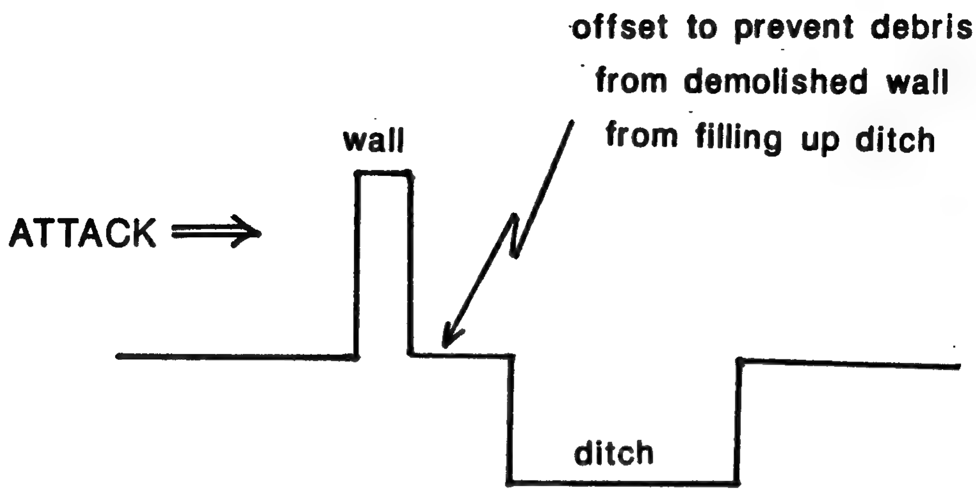


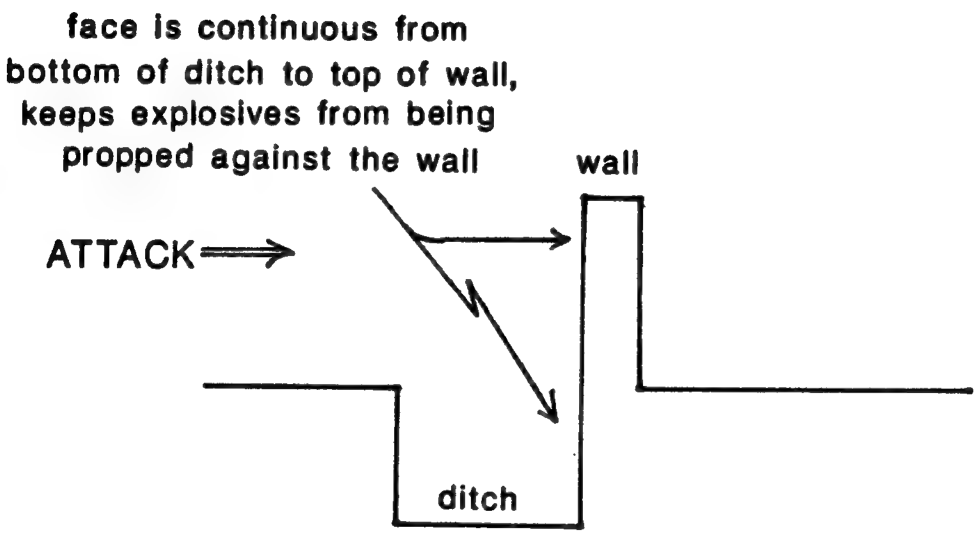

Figure 3-12. Values of *C*, the tamping factor, for breaching charges

Reproduced from Field Manual 5-25 Explosives and Demolitions

# FIGURE 3

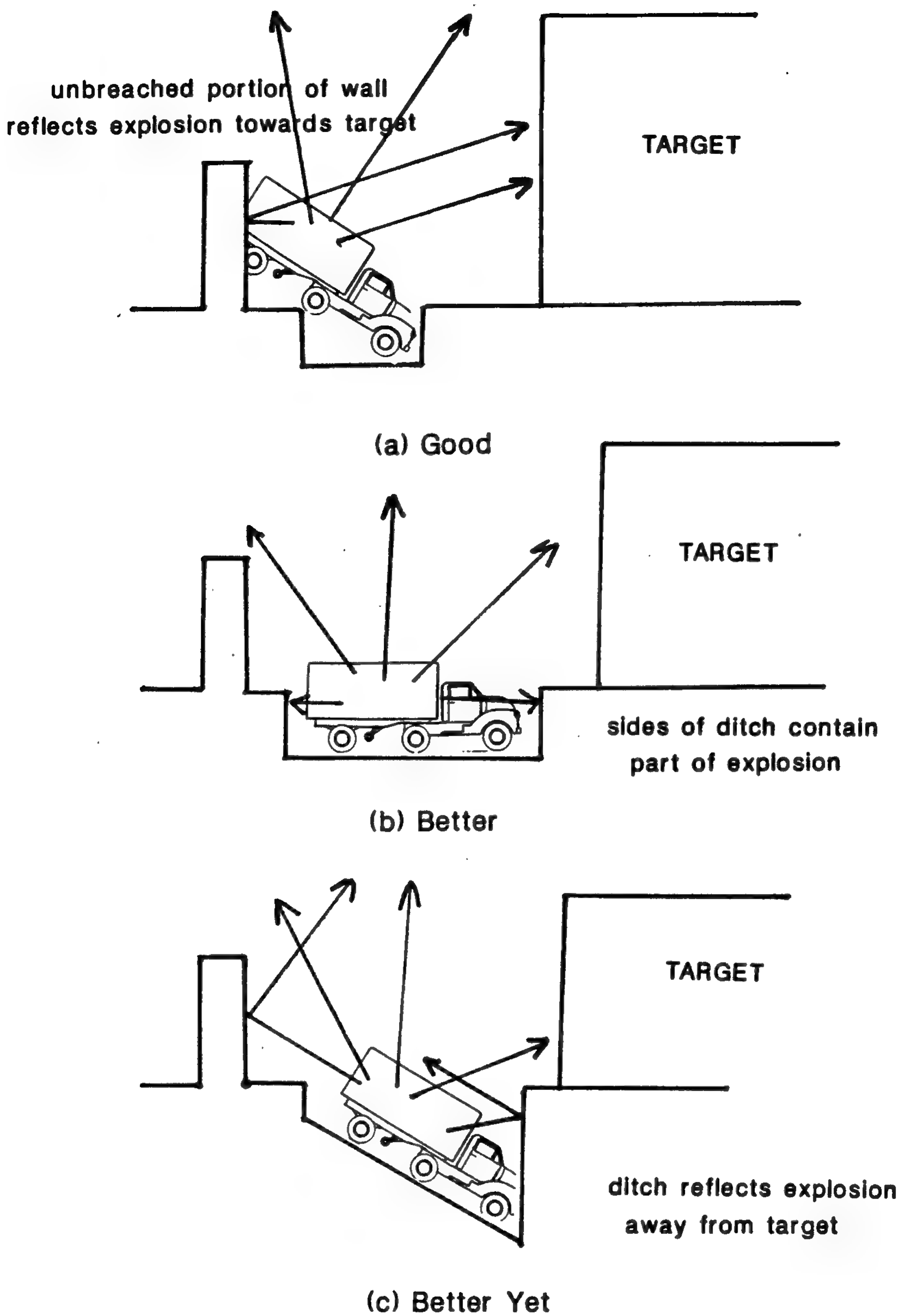



(a) wall precedes ditch




(b) ditch precedes wall

FIGURE 4

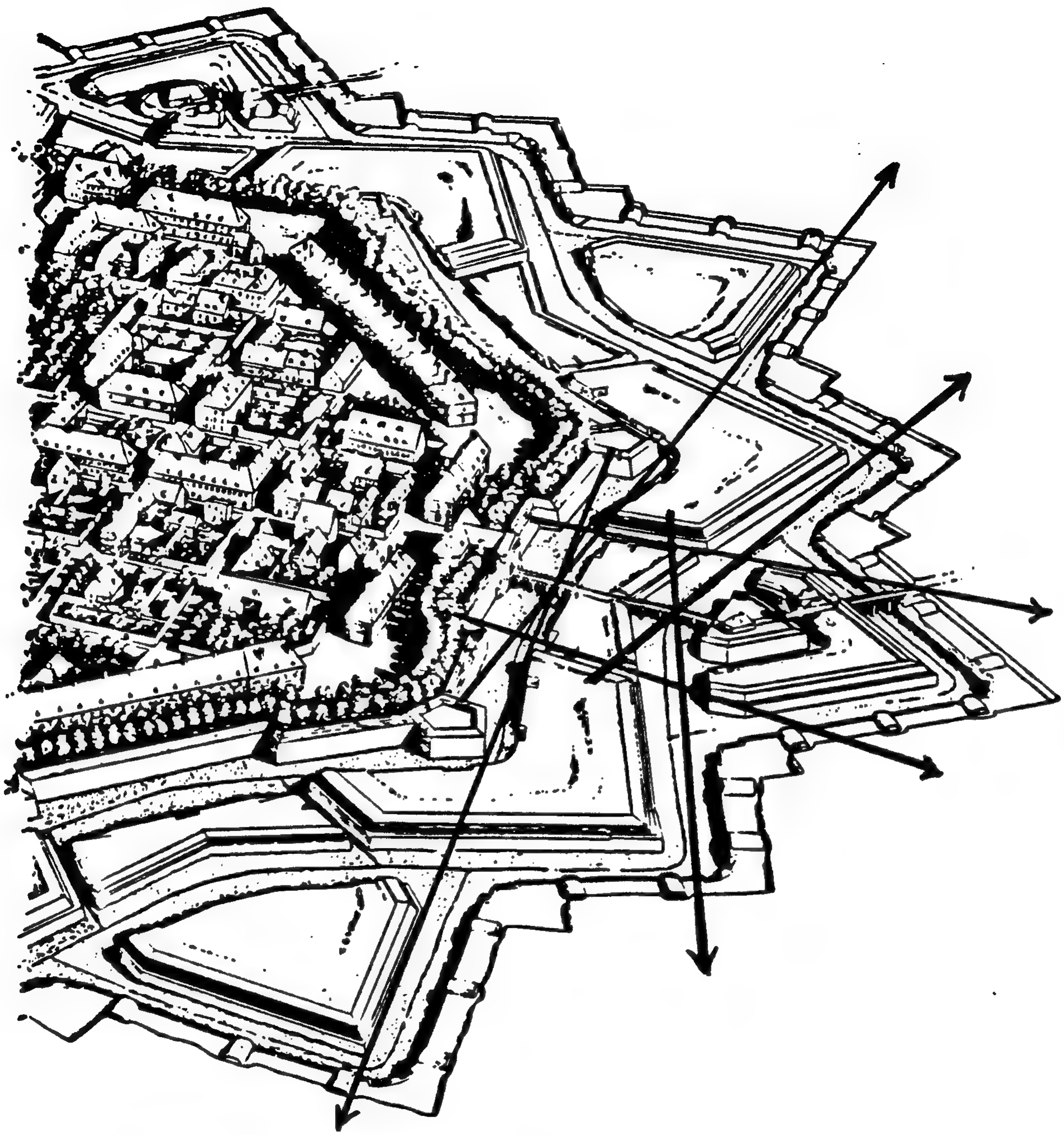



(a) Good

(b) Better

(c) Better Yet

FIGURE 5



Reproduced from The History of Fortification, by Ian Hogg, St. Martin's Press Inc, New York, 1981

FIGURE 6

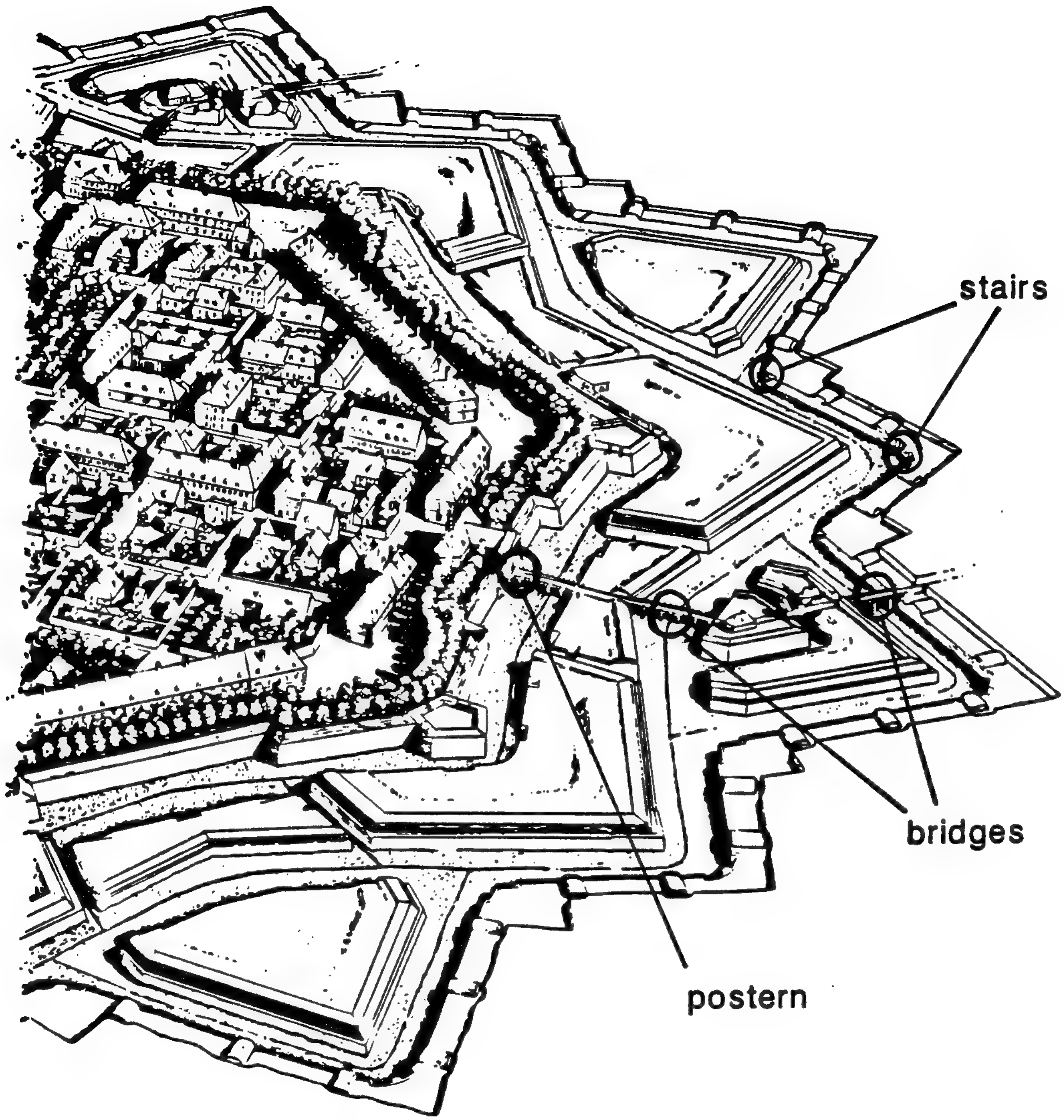



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FIGURE 7

## APPENDIX A

### PASSIVE SECURITY CHECKLIST

Passive security measures primarily involve principles of building design and protective barrier construction and location.

1. Define the threat.

STRUCTURAL DESIGN

2. Structural systems should be disguised to prevent targeting of critical elements.
3. The structural system should not be subject to catastrophic collapse.
4. Vulnerable/exposed areas should be structurally reinforced.
5. Outer buildings should screen inner buildings from destruction.

BLAST RESISTANCE FACTORS

To reduce damage from an explosion:

6. Use blast resistant materials of sufficient thickness.
7. Use obstacles to create maximum standoff between likely detonation zones and the building.
8. Confine explosions in the likely detonation zones.

PASSIVE OBSTACLE DESIGN

9. Design the dimensions of obstacles to exceed the breaching ability of the attackers.
10. Sequence obstacles and barriers so that the first obstacles prevent breach of the later obstacles.
11. Limit the number of passageways, and the dimensions of each passageway, to fit the traffic needs.

### ACTIVE SECURITY CHECKLIST

Active security measures incorporate all items in the Passive Security Checklist, plus the considerations for a security force.

1. Construct linear obstacles, preferably in depth, thus creating lines of observation within controlled zones of movement.
2. Forward observation points should be observed by rearward observation points.
3. Security forces should be sized based upon the inherent protection provided by the system of obstacles.
4. Linear obstacles should be observed along their entire length.
5. Obstacles should provide sufficient time for the security personnel to make judgment designs and react.
6. All entry points should be controlled, observed, and protected by not only the individuals manning the entrance, but also by more rearward security personnel.
7. Entry points should be designed so that they can be easily sealed.
8. The movement of security personnel should be concealed from outside view, but should be protected by rearward security.
9. Entry points require redundant safeguards.
10. Entry points should be recessed to restrict observation and provide protection.
11. The outside points from which an entry point can be viewed should be monitored.

ARMED SECURITY CHECKLIST

Armed security measures involve the considerations of active security measures with the additional considerations of weapons emplacement and force reaction. This checklist considers only anti-terrorist measures not counter-terrorist measures.

1. Security force positions should be sited to fire along linear obstacles.
2. Security force positions should be sited in depth, with forward positions covered by concealed rearward positions.
3. Passages for movement of security reaction forces should be protected from enemy fire, but covered by friendly fire.
4. Entry points should be recessed and covered by firing positions. Outside points from where the entry point can be observed should be kept clear.
5. Obstacles should be placed in depth to allow time for judgment decisions and reaction by security forces.
6. Entrances should be protected with redundant safeguards.

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# CAR-BOMB RELATED DEPARTMENT OF TRANSPORTATION TECHNOLOGIES

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"Conference on Securing Installations Against Car-Bomb Attack"
in
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TABLE OF CONTENTS

# CAR-BOMB RELATED DEPARTMENT OF TRANSPORTATION TECHNOLOGIES

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## ABSTRACT AND INTRODUCTION

The Texas Transportation Institute (TTI) has worked with the Federal Highway Administration (FHWA), American Association of State Highway and Transportation Officials (AASHTO), the National Cooperative Highway Research Program (NCHRP), the Transportation Research Board (TRB), and numerous state transportation agencies to develop barriers to safely restrain, stop, redirect, or yield to impacting passenger vehicles such as 1700 lb cars, 40,000 lb buses, and 80,000 lb trucks. The technologies and analytical models used to design and develop these safety barriers can readily be used to design and develop barriers to stop, roll over, or demolish impacting vehicles (cars, buses and trucks). It is believed that many of these vehicle barriers can be designed to resist and/or shield selected areas from explosive blast effects. Some of these barriers are massive, reinforced concrete walls 7.5 ft high, massive earth mounds several feet high, and ditches or moats.

Mathematical models which describe the dynamic behavior of motor vehicles impacting barriers and traversing embankments of various heights and slopes are available for immediate use in designing such barriers. The magnitude of the vehicle impact forces which barriers must resist and the required heights of these barriers are now well understood.

This paper will present examples of some of the barriers and technologies available. Examples of barriers that can resist vehicle impact penetration and explosion are presented. It is believed that these barriers can be aesthetic and attractive also.

## MATHEMATICAL MODELS

Figure 1 shows the synthesis and simulation of a vehicle/rigid-barrier collision, first published by Emori of UCLA (1)*. After observing the results of many full-scale vehicle crash tests involving a rigid barrier, Emori concluded that the crushing of the vehicle front end could be simulated as a lump mass and one spring. From full-scale test data, he observed that the spring stiffness of the front end of the vehicle could be closely approximated by 12.5 times the vehicle weight. The spring exhibits no restitution. This approximation was found to be within about ±20 percent accuracy.

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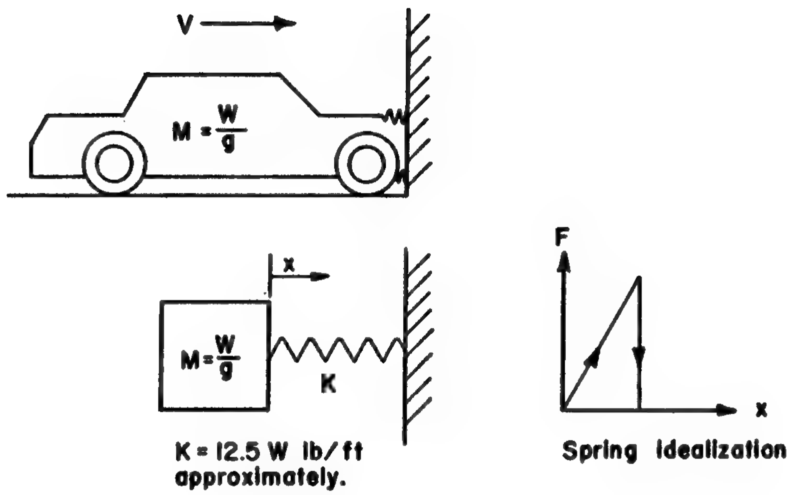
*Underscored numbers in parenthesis, thus (1), refer to corresponding items in Reference List.




$$-Kx = M\ddot{x} \qquad \text{where B.C. are } t=0,\ x=0,\ \dot{x}=V$$

$$\ddot{x}+\omega^2 x = 0 \qquad \text{where } \omega^2 = K/M$$

Solution $x = (V/\omega)\sin\omega t$

$$\dot{x} = V\cos\omega t$$

$$\ddot{x} = -V\omega\sin\omega t$$

$$G_{max} = \ddot{x}_{max}/g = -V\omega/g = -.62V_{fps} \text{ or } -.9V_{mph} = G_{max}$$

$$G_{avg} = G_{max}(2/\pi) = -.58V_{mph} = G_{avg}$$

FIGURE 1. SIMULATION OF RIGID-BARRIER COLLISION

Following the solution of the homogenous linear differential equation, one will find that the maximum deceleration of the vehicle is equal to 0.9 times the vehicle impact velocity in miles per hour. The average deceleration of the vehicle during the collision is 0.58 times the vehicle velocity in miles per hour. For example, in a 60 mph rigid barrier collision, the vehicle will be subjected to a maximum deceleration of 0.9 times 60, yielding 54 g's. The average deceleration of a vehicle will be 0.58 times 60, or 35 g's. If one further examines the solution to the differential equation, it will be found that the duration of the collision is 0.080 sec. This relatively simple simulation of a vehicle/rigid-barrier collision is extremely useful for comprehending the magnitude of the decelerations imposed on such a vehicle and the collision forces involved. If an engineer were required to design a rigid barrier to resist the 60 mph head-on impact of a 4,000 lb vehicle, it is apparent that the barrier must resist a force of 4,000 lb times the peak deceleration of 54 g's or 216,000 lb. The total kinetic energy of the vehicle is absorbed by the crushing of its front end.

## MATHEMATICAL MODEL OF A VEHICLE/BARRIER RAILING COLLISION

A simple mathematical model of a vehicle/barrier railing collision is shown by Figure 2. Observations of high-speed films and sequence photographs led to the development of the equations presented (2).

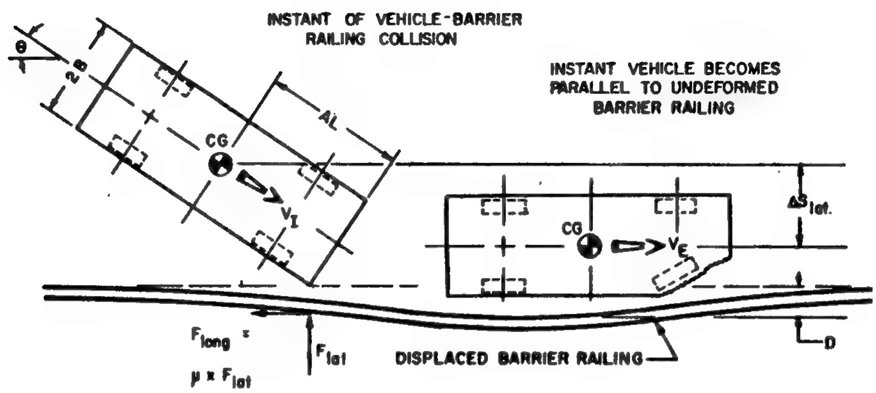
These equations express the average vehicle decelerations as a function of: (1) type of barrier railing -- rigid or flexible, (2) dimensions of the vehicle, (3) location of the center of mass of the vehicle, (4) impact speed of vehicle, (5) impact angle of the vehicle, and (6) coefficient of friction between the vehicle body and barrier railing.

Peak or maximum 50 millisecond average decelerations can be three times the average values computed for rigid barriers with equations from Figure 2.

The equations developed here can be used to design traffic rails for a selected vehicle weight (W), impact angle ($\theta$), and impact speed ($V_1$). The rail must have adequate strength to resist the collision forces (lateral and longitudinal). The rail can also be designed to be flexible to provide lateral deformation (D) which in turn will minimize the decelerations on the vehicle and magnitude of the impact force on the barrier. Since the final vehicle velocity ($V_E$) can be computed, the change in vehicle kinetic energy can be computed. The crushing of both the vehicle and barrier and the energy dissipated by friction between the barrier and vehicle must account for the change in kinetic energy. If structural analysis of the barrier indicates it is not capable of absorbing the required energy, it is obviously inadequate.

More sophisticated math models and computer programs are available for evaluating vehicle-longitudinal barrier impacts.

GUARD - GUARD is a three-dimensional vehicle-longitudinal barrier program (3). It was originally developed to evaluate the effect of the collapsing bumper system on automobiles when impacting longitudinal rail systems. GUARD has been used in the design and analysis of rigid and semi-rigid rail systems. It was also used to study the impact performance of barriers on non-level terrain. TTI researchers are familiar with the




Avg. $G_{lat.} = \dfrac{\Delta V_{lat.}}{\Delta t\ g}$ and avg. $G_{long.} = \dfrac{\Delta V_{long}}{\Delta t\ g}$

Since $\Delta V_{lat.} = V_I \sin\theta$ and $\Delta V_{long.} = V_I \cos\theta - V_E$

and $\Delta t = \dfrac{\Delta S_{lat.}}{V_{lat.avg.}} = \dfrac{AL\sin\theta - B(1-\cos\theta) + D}{1/2\ V_I \sin\theta}$

then

$$\text{avg. } G_{lat.} = \frac{V_I^2 \sin^2\theta}{2g\left[AL\sin\theta - B(1-\cos\theta) + D\right]}$$

$$\text{avg. } G_{long.} = \mu G_{lat.}$$

Exit speed $V_E = V_I(\cos\theta - \mu\sin\theta)$

FIGURE 2. SIMULATION OF VEHICLE - TRAFFIC RAIL COLLISION

capabilities and limitations of GUARD and have made changes to enhance its utility and capabilities. Reasonably good results have been obtained for simulation of two-dimensional types of vehicle-barrier impacts into conventional rigid or semi-rigid barriers. The extremely complex nature of a three-dimensional vehicle-barrier impact presents a major challenge to GUARD and to any other existing code. Accurate simulation of large, nonlinear barrier and vehicle displacements and nonlinear material properties, nonlinear soil properties, tire-barrier interaction, and snagging and/or underriding are formidable tasks. Only experienced researchers should attempt to use GUARD and other vehicle-barrier codes when simulating complex three-dimensional barrier impacts where penetration, override, or underride may occur.

CRUNCH - CRUNCH is an extension of GUARD and was intended for use in simulating a variety of vehicles and barrier types. Among other features, it was intended for use in evaluating articulated vehicle-barrier imports, including crash cushions.

BARRIER VII - BARRIER VII has been applied at TTI on several projects, including "Weak Post Barrier Systems", "Test and Evaluation of a High Performance Median Barrier", "Design and Analysis of High Performance Barrier Systems", "Development of Safer Barriers for Construction Sites", and others. The program (4) has proven to be a valuable tool in the design and analysis of longitudinal barrier systems, especially those that exhibit two-dimensional response. The vehicle model employed in BARRIER VII is a "gross" representation of an actual vehicle and therein lies one of its major limitations, in addition to its two-dimensional limitation. BARRIER VII can be used in evaluating barrier structural adequacy, but it would have little value in predicting override or underride directly.

## MATHEMATICAL SIMULATION OF VEHICLE NET OR SNAGGING DEVICE

The Entwislle Company of Massachusetts uses a fence or net attached to a "metal bender" energy absorber to stop speeding vehicles. In Figure 3 the metal tape tension, or "drag force" (T), will usually be constant. The designer must select the proper combination of "drag force" (T) and tape run-out distance (R) so the device will stop the selected design vehicle weight and speed. From the simple geometry of Figure 5, it can be seen that the relationship between stopping distance (D) and tape run out (R) is

$$D = R^2 + RL \text{ or } R = \frac{-L + \sqrt{L^2 + 4D^2}}{2} \text{ (approximately)}$$

Chain link fences and other type fences can similarly be designed to stop a selected vehicle weight and speed.

## MATHEMATICAL MODEL OF AN AUTOMOBILE

The mathematical model described herein (HVOSM) was used to investigate the dynamic behavior of an automobile traversing embankments of various heights and slopes. In general, the model can be utilized to investigate a variety of problems associated with the roadway environment, such as highway traffic barrier collisions, rigid lane change maneuvers, handling response on horizontal curves, drainage ditch cross sections, and others.

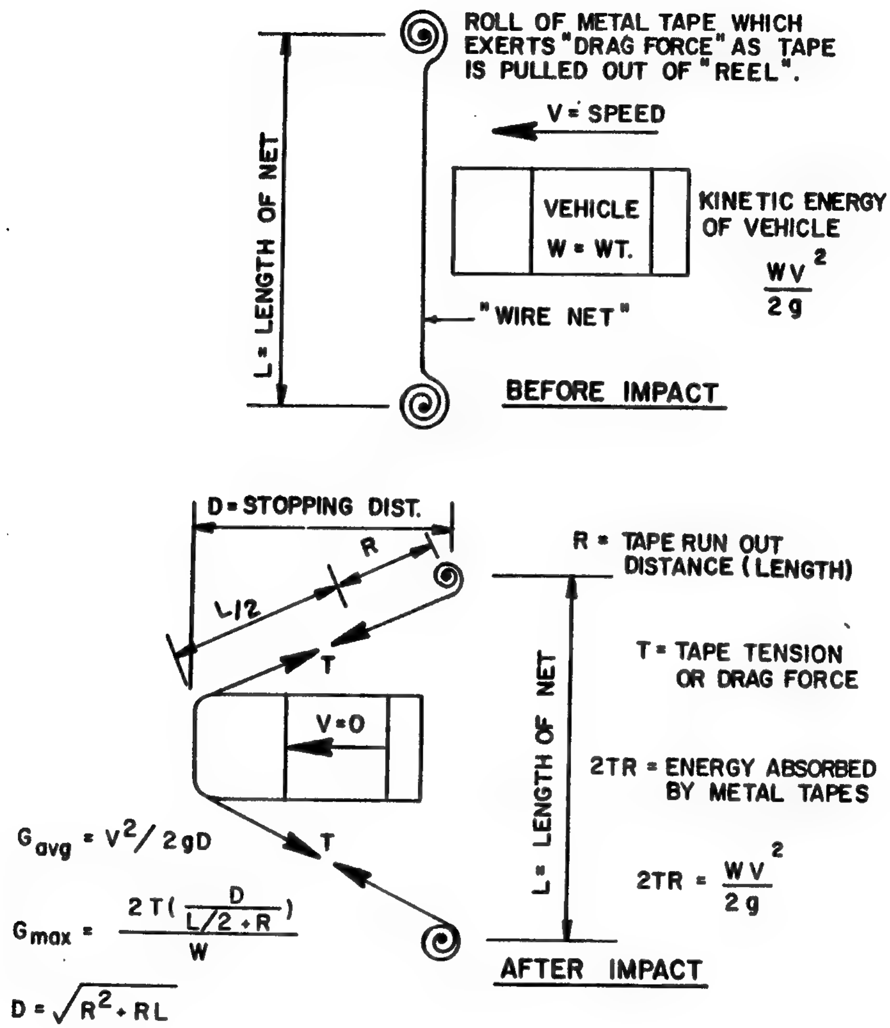



FIGURE 3. PRINCIPLE OF ABSORBING VEHICLE KINETIC ENERGY - NETS OR SNAGGING DEVICES

The mathematical model was developed by Cornell Aeronautical Laboratory (5) and later modified for specific problem studies by the Texas Transportation Institute (6). A conceptual idealization of the model is shown in Figure 4. The model is idealized as four rigid masses which include: (a) the sprung mass ($M_s$) of the body supported by the springs, (b) the unsprung masses ($M_1$ and $M_2$) of the left and right independent suspension system of the front wheels, and (c) the unsprung mass ($M_3$) representing the rear axle assembly.

The eleven degrees of freedom of the model include translation of the automobile in three directions measured relative to some fixed coordinate axes system, rotation about the three coordinates of the automobile, independent displacement of each front wheel suspension system, suspension displacement and rotation of the rear axle assembly, and steerage of the front wheels.

The validity of the model is dependent to a large extent on the accuracy of the input parameters pertaining to the automobile selected.

Mathematical simulation provides a rapid and economical method of investigating the many parameters involved as an automobile traverses some defined roadway configuration. Once the limiting parameters are identified, it may be desirable to conduct a limited number of full-scale tests prior to final selection of a particular design. This approach, in contrast to a full-scale, trial-and-error approach, will yield more meaningful results with considerably less resource expenditure.

Figure 5 shows an HVOSM computer simulation of a car impacting a concrete median barrier compared to an actual crash test (7).

Figure 6 shows the HVOSM computer simulation of a car negotiating a culvert grate slope (8,9). Figure 7 is a similar impact at a different angle of approach. In both cases the vehicle rolls over. In designing terrorist car-bomb barriers, we would want to design sloped earth berms which would roll over or stop the vehicle and resist the explosion.

Figure 8 shows the impact of an automobile into a 40° earth slope at 40 mph and 15° angle which resulted in vehicle rollover (10). Various other slopes or combinations of slope can be designed to achieve similar behavior (11,12). Figure 9 shows a car impacting a 3.8 to 1 slope (15° slope) head-on at a speed of 50 mph (13). The car launched high into the air and pitched over as shown also in Figure 6.

## SUMMARY OF VEHICLE AND LONGITUDINAL BARRIER PROPERTIES TO BE CONSIDERED IN RESTRAINING VEHICLE

Most all current longitudinal barriers (guardrails, bridge rails, and median barriers) are designed only to restrain and redirect passenger cars ranging in weight from 1700 lb to 4500 lb. The recommended strength test is for a 4500 lb car to be redirected at 60 mph and 25° angle impact. Figure 10 shows some basic properties of these cars and two very common and effective longitudinal barriers which can restrain and redirect them (14). These cars have center of gravities (c.g.'s) ranging from 18 in. to 24 in. above the roadway. The 27 in. high standard guardrail and 32 in. high concrete safety

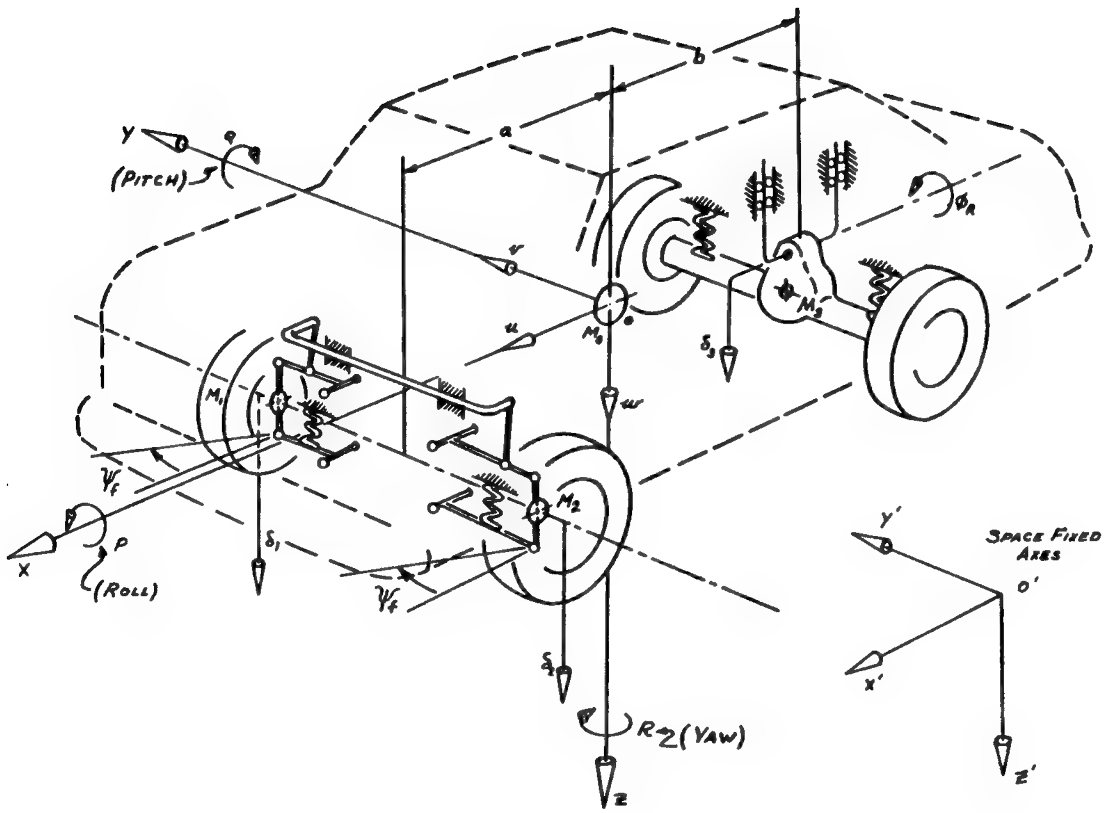



FIGURE 4. IDEALIZATION OF AUTOMOBILE

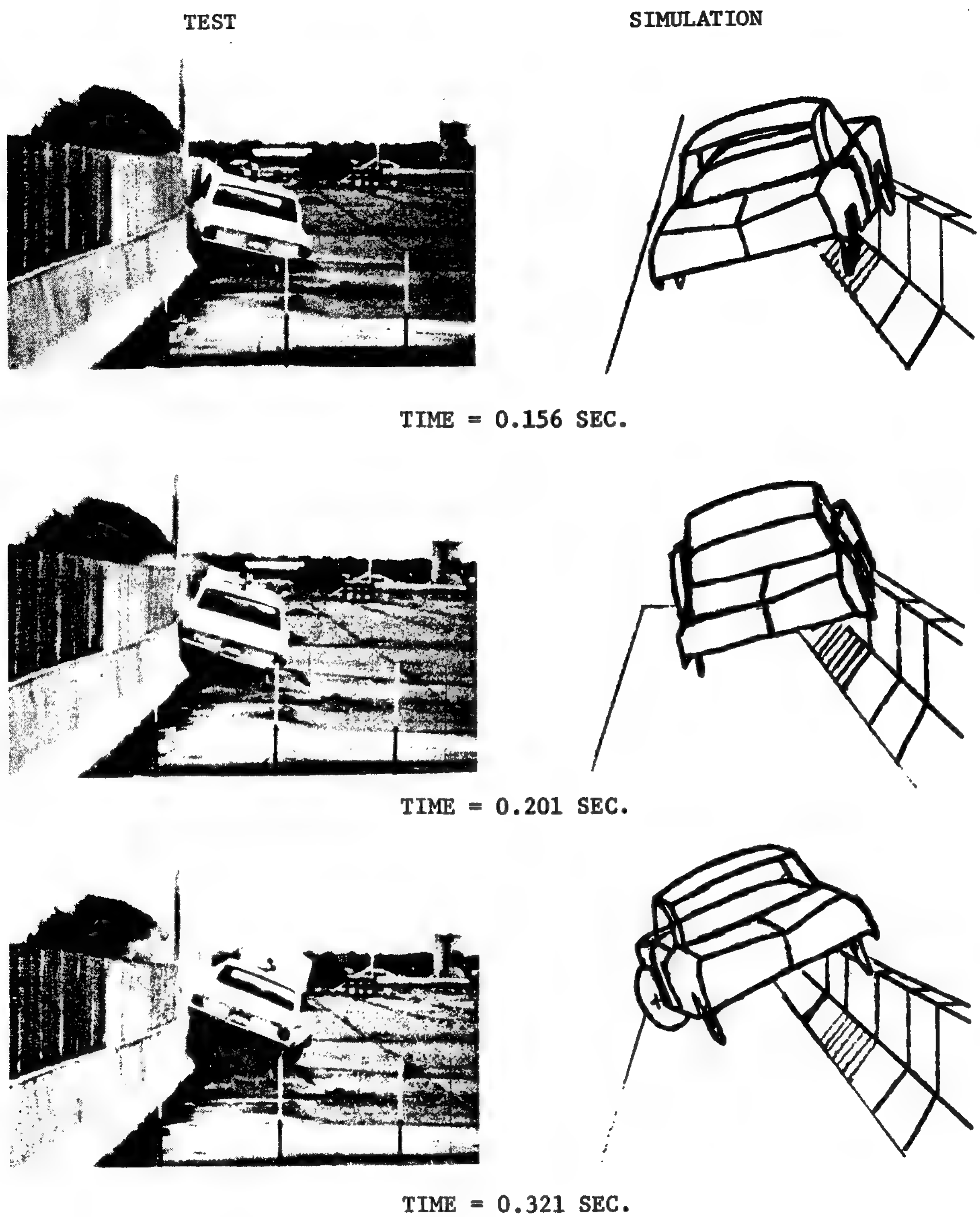



FIGURE 5. - COMPARISON OF COMPUTER SIMULATION WITH TEST RESULTS FOR 4000 LB. VEHICLE IMPACTING CONCRETE MEDIAN BARRIER AT 63 MPH AT 25 DEGREES; TIME = 0.156 SEC. TO 0.321 SEC.

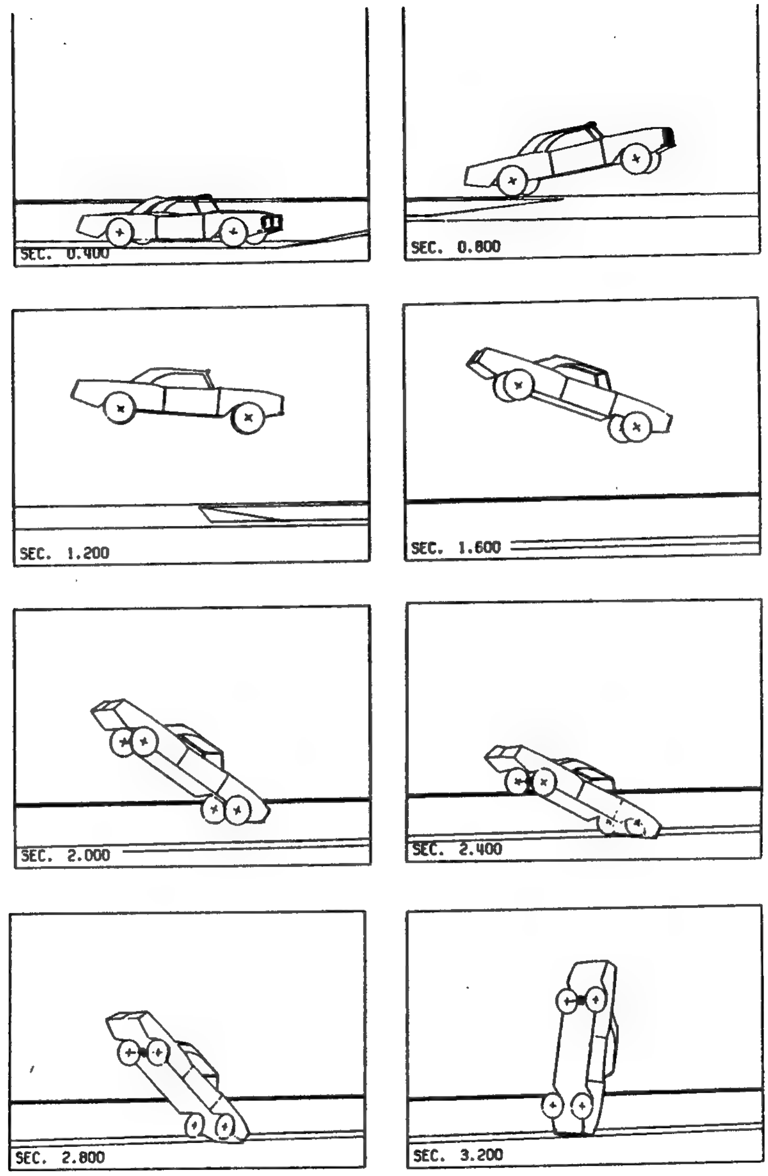



FIGURE 6. HEAD-ON 60 MPH SIMULATION OF AUTOMOBILE NEGOTIATING A 6:1 CULVERT GRATE SLOPE



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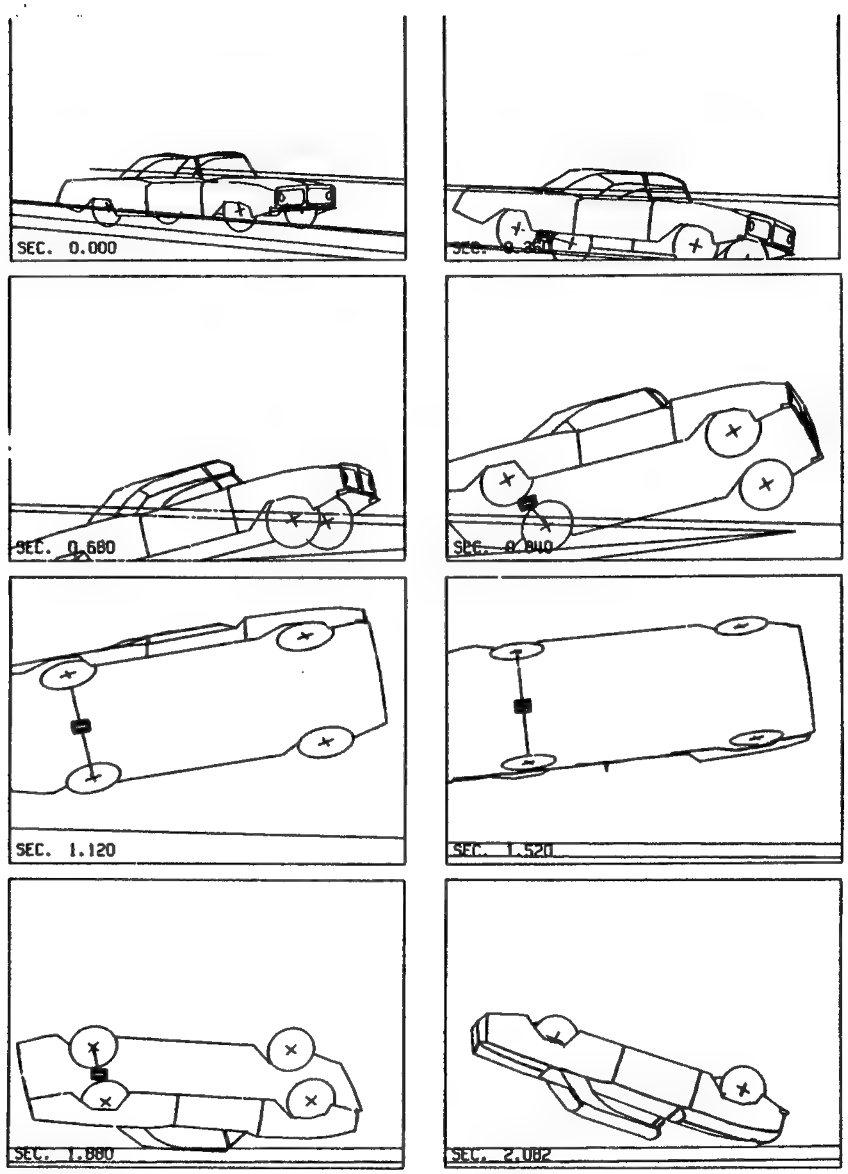


FIGURE 7. 60 MPH/25 DEG SIMULATION OF AUTOMOBILE NEGOTIATING 6:1 SIDE SLOPE AND 6:1 CULVERT GRATE SLOPE



000365

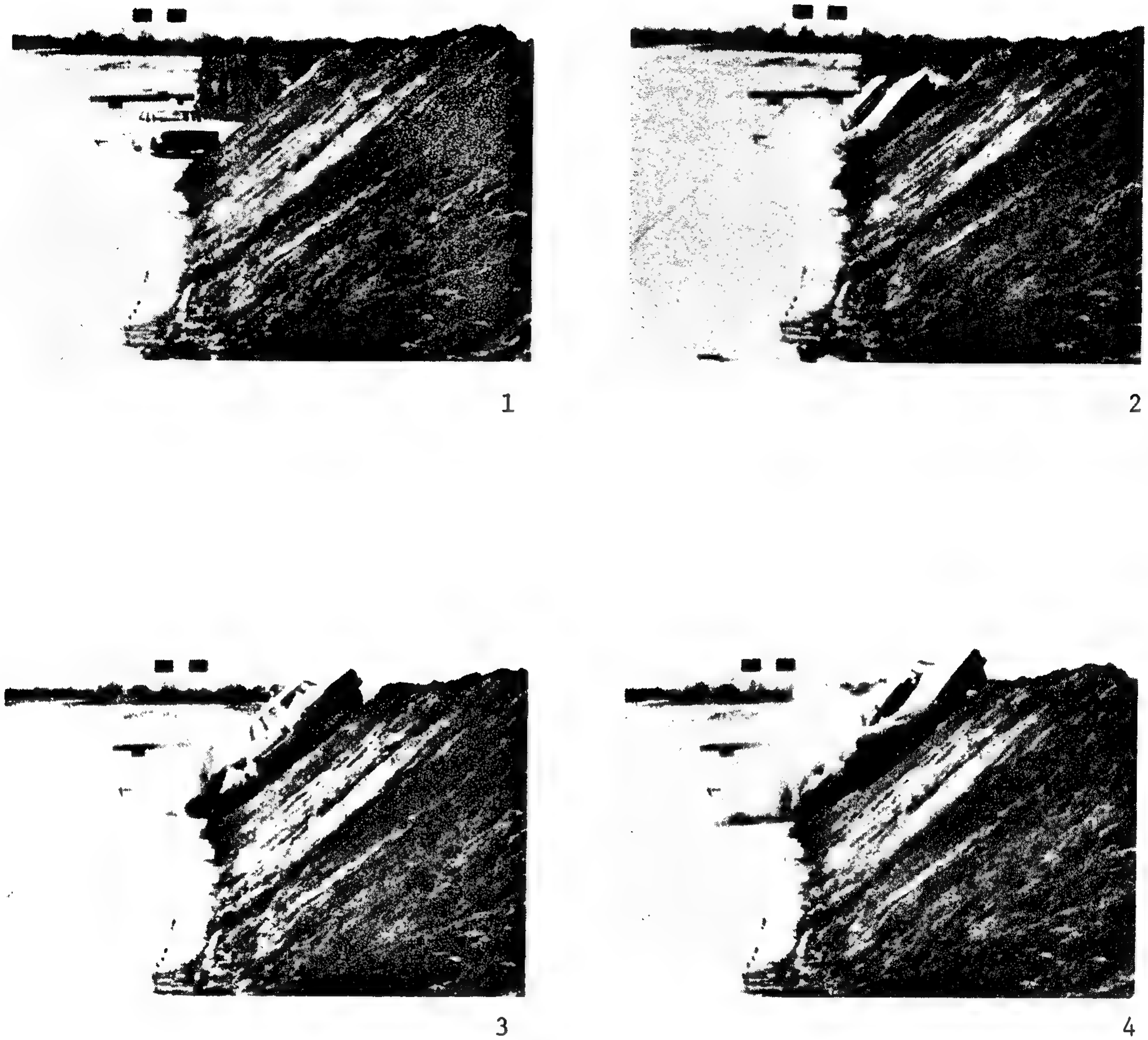


FIGURE 8. SEQUENTIAL PHOTOGRAPHS OF TEST NO. 5
40.3 mph, 15° APPROACH ANGLE,
40° SLOPE (1.2:1)

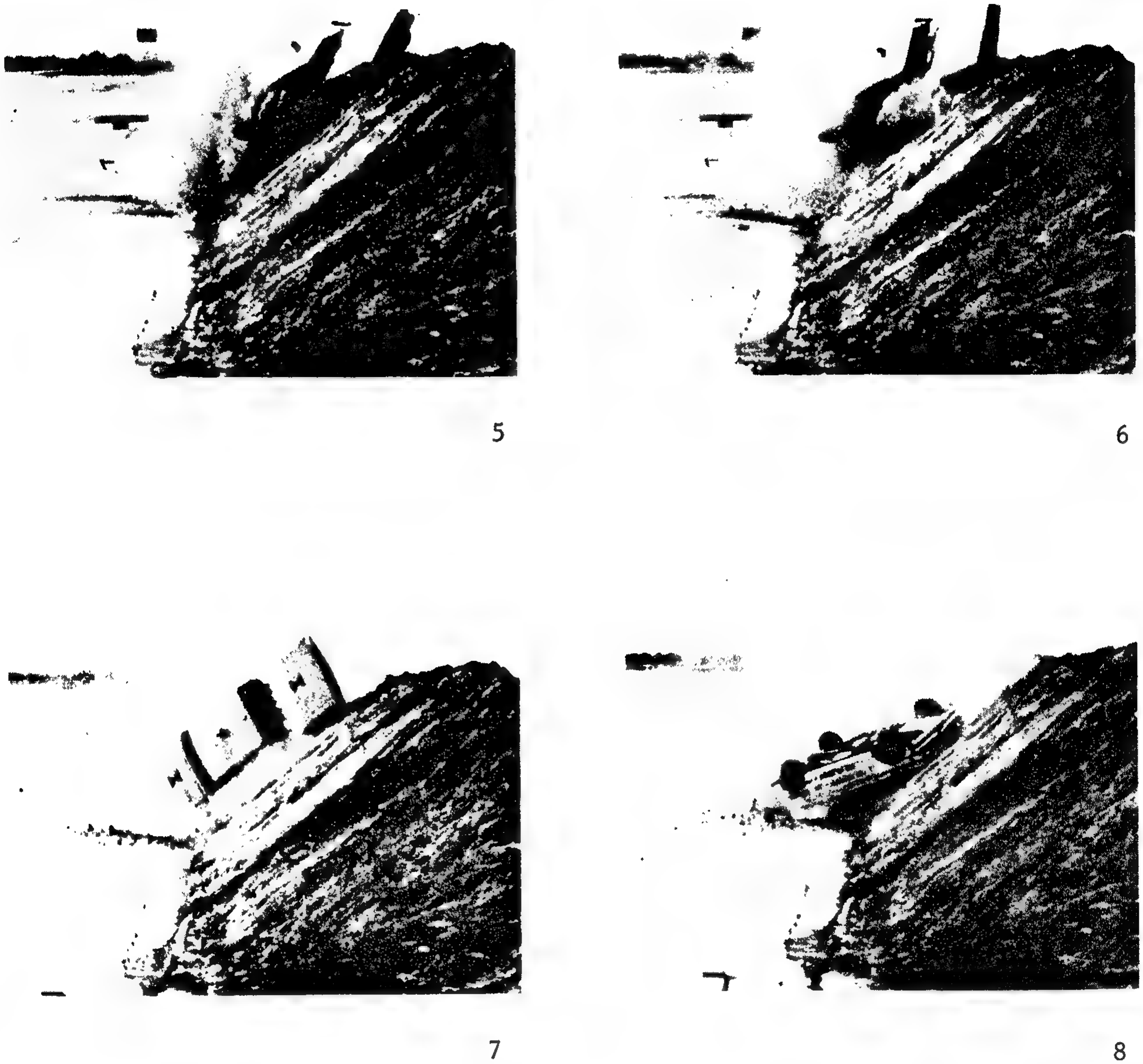


FIGURE 8. (continued)

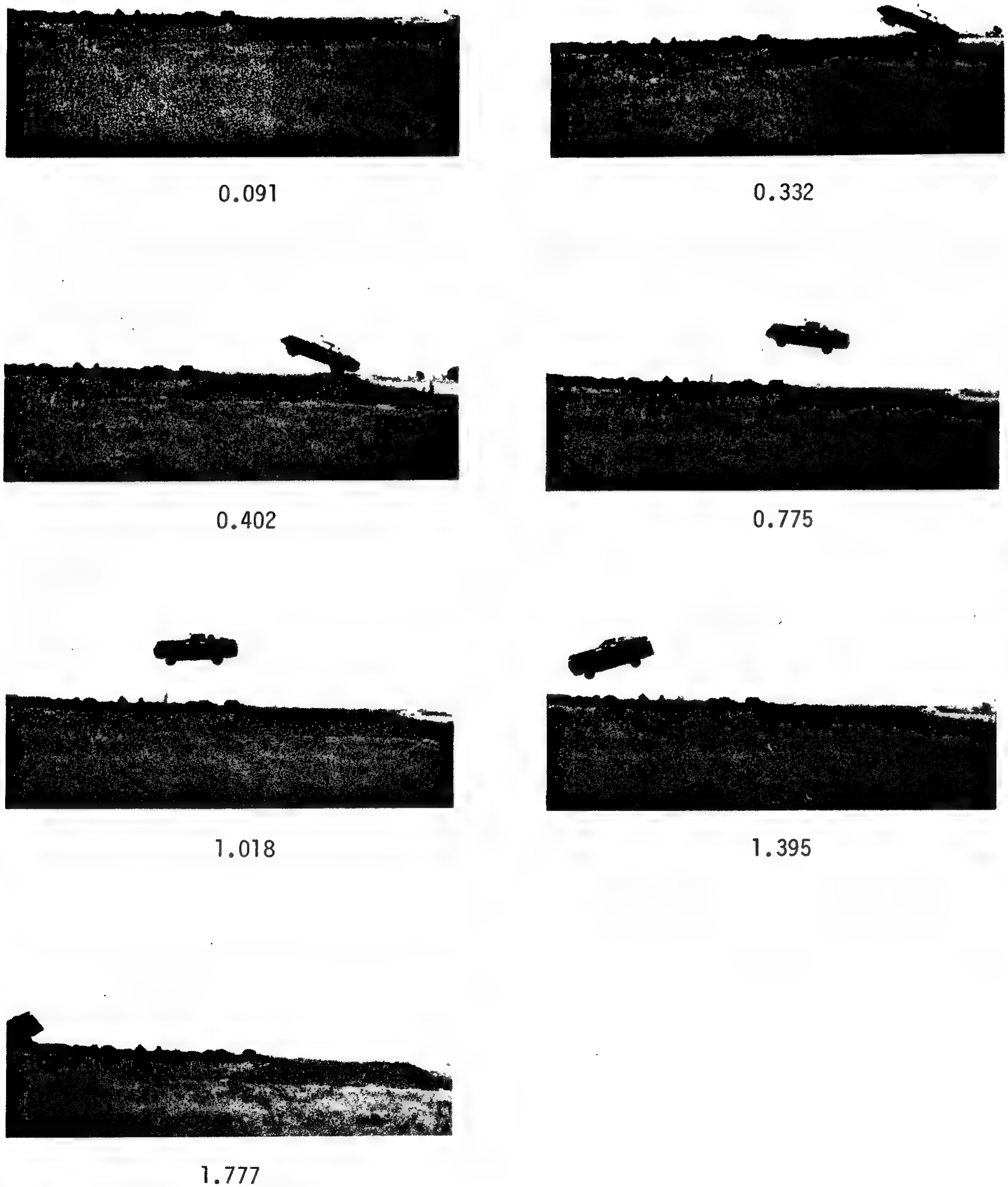


FIGURE 9. SEQUENTIAL PHOTOS, TESTS 1-4

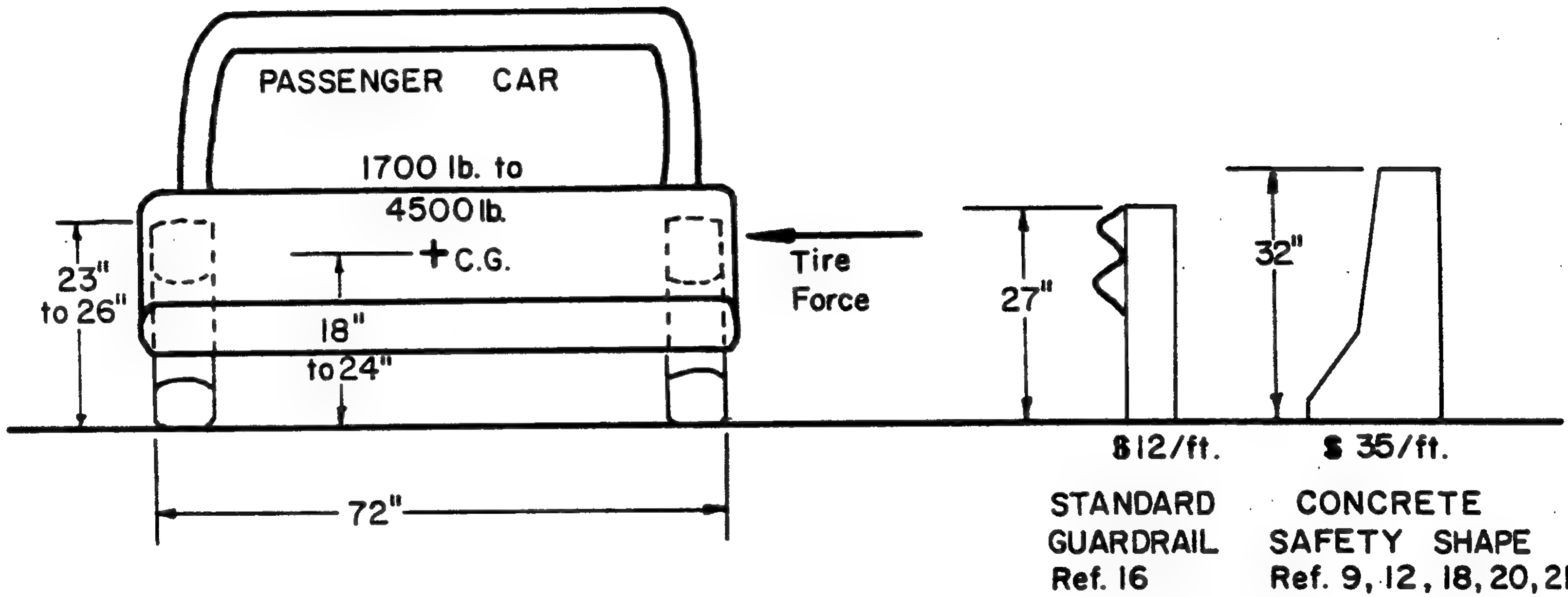


FIGURE 10. BASIC PROPERTIES OF PASSENGER CARS AND EFFECTIVE LONGITUDINAL BARRIERS

shape are strong enough to redirect the cars and high enough to prevent rollover (17,18). These barriers exert a redirecting and stabilizing force on the fenders, tires, and door panels of the impacting car, as shown in the figure. The approximate cost per foot of these traffic barriers is shown for comparison purposes.

Figure 11 shows some basic properties of buses (school and intercity) and two longitudinal barriers which have restrained and redirected them. School buses (66 passenger) generally weigh from 20,000 to 26,000 lb loaded. Intercity buses (45 passenger) generally weigh from 32,000 to 40,000 lb loaded. The center of gravity of these buses ranges from 46 in. to 58 in., with an average of about 2 in. The two minimum height rails which have prevented these buses from rolling over at 60 mph, 15° angle impact (the recommended test 6) are the two shown with heights of 38 in. and 42 in. The approximate cost per foot of the barrier is shown for comparison purposes.

Traffic barriers 32 in. and 34 in. high have consistently produced rollover with buses at 60 mph and 15° angle of impact. The significant redirection force from these barriers is delivered to the bus through the front and rear tires and axles. The largest impact force occurs when the rear tires and axle impact the barrier.

Figure 12 shows some basic properties of van and tank-type trucks and some longitudinal barriers which have restrained and redirected them (19,20, 21,22,23,24,25). These trucks weigh from 25,000 lb empty up to 80,000 lb when fully loaded. The center of gravity of an empty truck can be about 45 in., while a fully loaded truck could have a center of gravity of from 60 in. up to 78 in. Figure 12 shows three distinct locations or heights where a longitudinal barrier can effectively push on a van or tank truck to redirect it. A 42 in. high barrier can push on the 42 in. high tires and axle. For a van-type truck, the floor system from 48 in. to 54 in. high is capable of receiving a significant redirection force. Above this height the van truck generally has a very thin and weak sidewall not capable of receiving much redirection force.

A tank truck can receive a redirection force through the tires up to 42 in. high and then another redirection force at about 84 in. high into the central area of the usually circular tank.

The 42 in. high concrete median barrier shown redirected without rollover an 80,000 lb van truck with 65 in. high center of gravity. A similar truck with 78 in. high center of gravity rolled over the 42 in. high barrier (16). All these tests are at the recommended speed of nominally 50 mph and 15° angle impact.

## SUMMARY OF STRENGTH AND HEIGHT REQUIREMENTS OF LONGITUDINAL BARRIER

Reference 14 presents a summary of normal strength and height requirements of longitudinal barriers. Figure 13 shows a summary of the maximum 0.05 sec impact force that motor vehicles of various types and sizes can impose on a rigid-to-stiff barrier (16). If the barrier is flexible and deforms, the impact force can be reduced considerably.

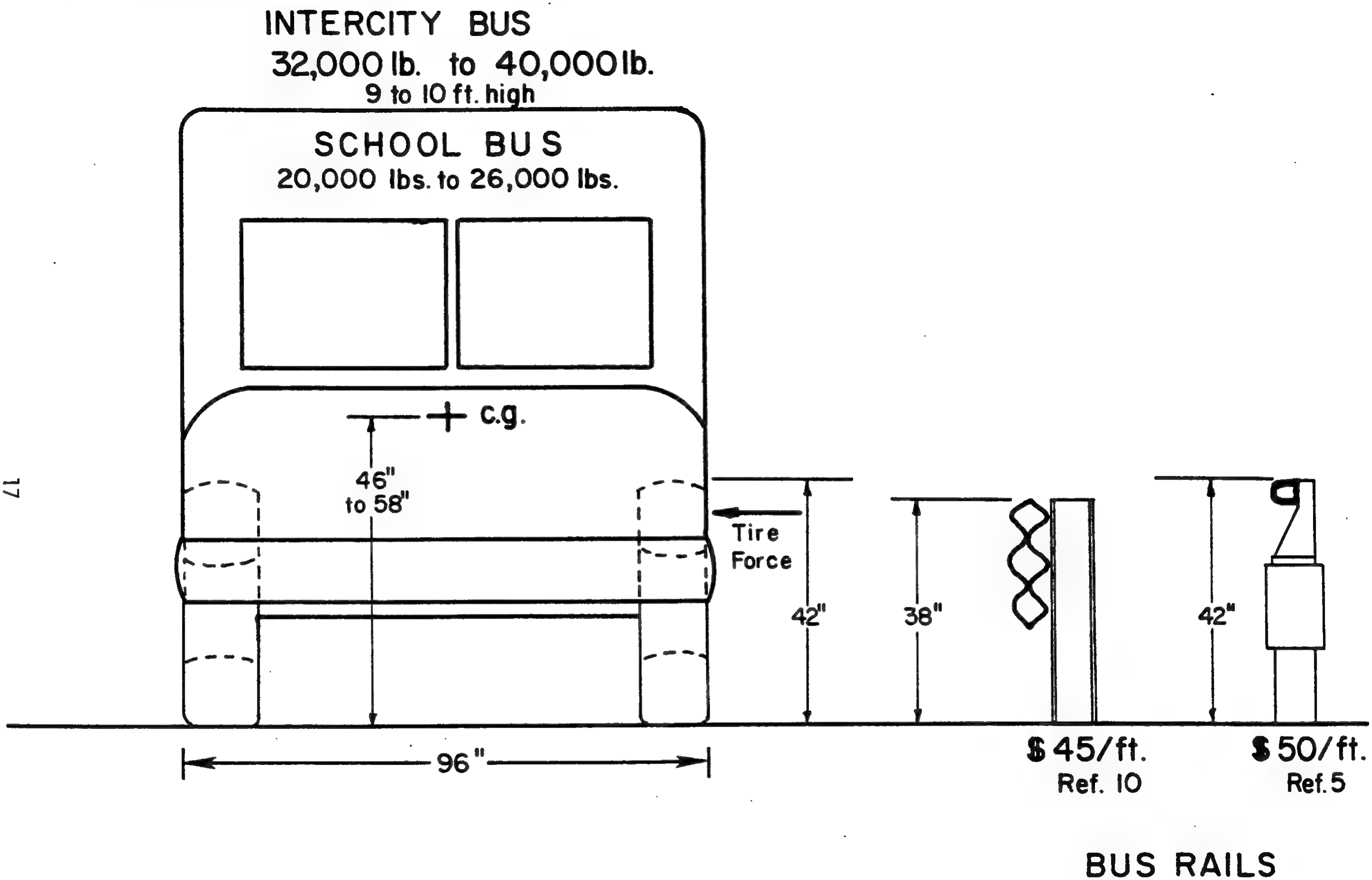


FIGURE 11. BASIC PROPERTIES OF BUSES AND TWO EFFECTIVE LONGITUDINAL BARRIERS

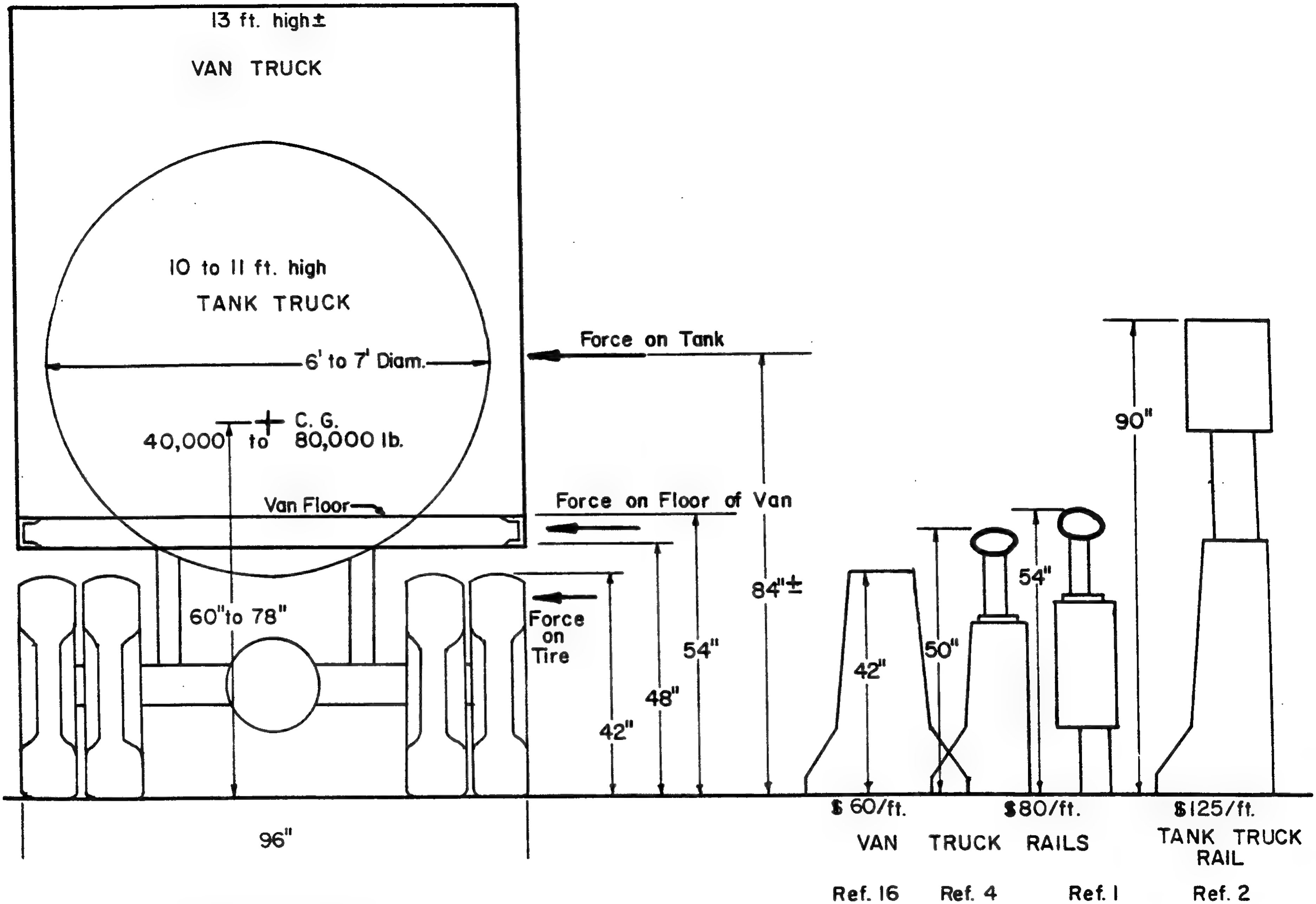


FIGURE 12. BASIC PROPERTIES OF TRACTOR-TRAILER TRUCKS (VAN AND TANK TYPES) AND SOME LONGITUDINAL BARRIERS WHICH HAVE RESTRAINED AND REDIRECTED THEM

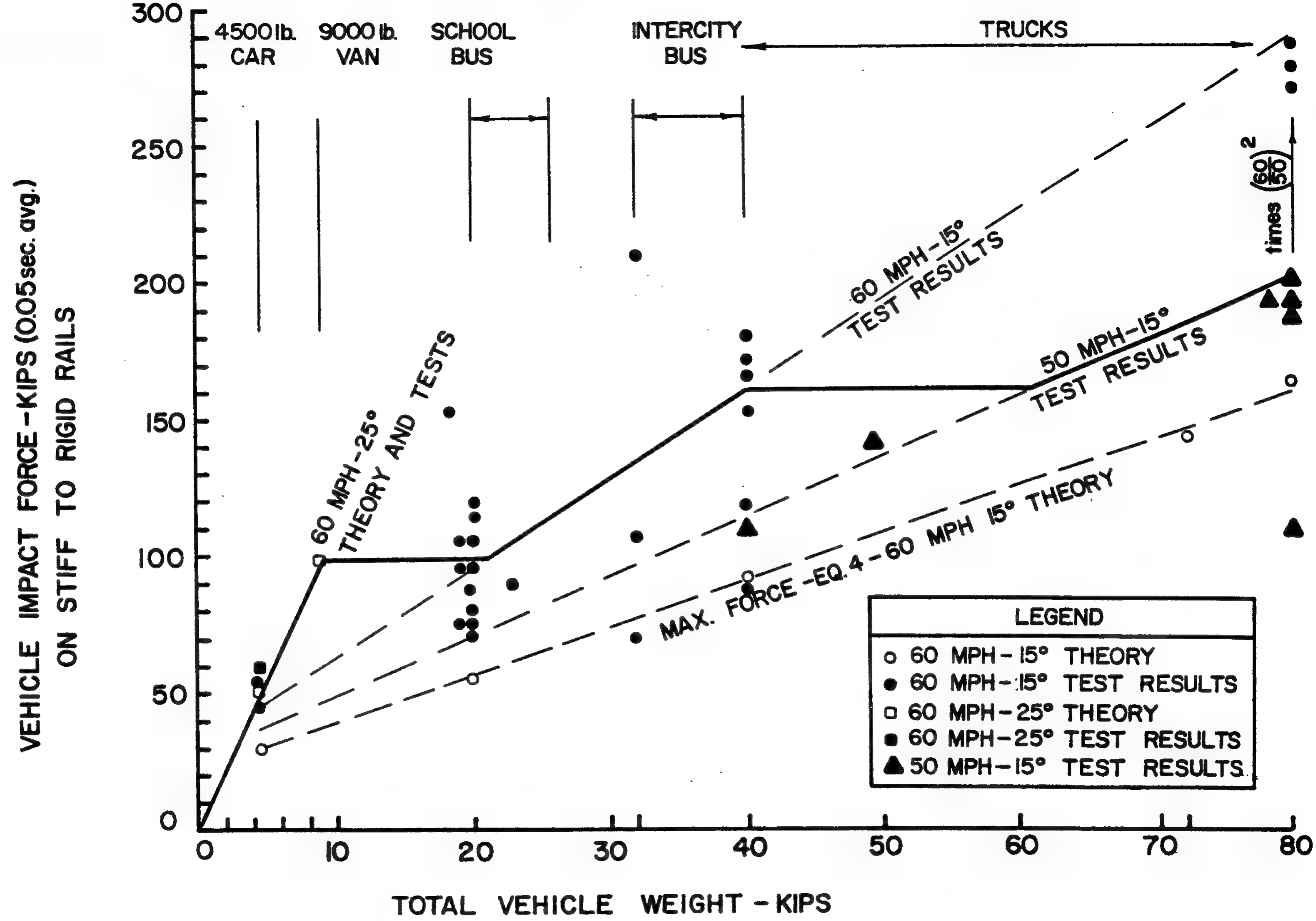


FIGURE 13. COMPARISON OF VEHICLE IMPACT FORCES TO TOTAL VEHICLE WEIGHT-THEORY AND TEST RESULTS-STIFF RAILS

Figure 14 shows a summary of the height requirements for such barriers if one wants to prevent the impacting vehicle from rolling over. In our case, we probably do not care if the car-bomb vehicle rolls over.

The data on Figures 13 and 14 should be useful in designing barriers capable of restraining and/or rolling over selected car-bomb vehicles.

## POTENTIAL LONGITUDINAL BARRIERS TO RESIST CAR-BOMB IMPACT AND EXPLOSION

Barriers to resist car bomb attacks could range from a simple chain link fence (15) or other steel fencing if enough safe distance is available to separate inhabited buildings, etc., from the fence and explosion to a massive reinforced concrete barricade if little-to-no separation distance is available.

Figure 15 indicates that if we have available 400 ft to 800 ft separation distance, we only would need a properly designed fence to restrain and stop the car-bomb vehicle containing 500 to 1000 lb of TNT (26).

Figure 16 indicates that if we have little-to-no separation distance, we would need 6 ft of reinforced concrete wall for protection (27). Figures 15 and 16 come from Reference 26 and two years of experience in the U.S. Army Corps of Engineers (Ft. Belvoir, Ft. Polk, and Inchon). Figure 16 also shows that a 10 ft thick precast concrete double wall filled with soil could also resist such an explosion (see Appendix A and Reference 28). Figure 16 also indicates a 16 ft thick soil embankment could resist such an explosion.

With this information in mind, Figure 17 shows a simple, inexpensive vehicle barrier fence when 400 to 800 ft separation distance is available.

Figures 18 and 19 show how the HVOSM mathematical model of a car could be used to design ditch and earth berms which could restrain motor vehicles and explosions when about 30 to 60 ft of separation distance is available. In Figure 18 the combination of **ditch slope** and **earth berm slope** is important to stop or roll over the vehicle.

Figure 20 shows a combination traffic barrier placed in front of a concrete and soil double wall explosion barrier. The precast concrete DOUBLEWALL filled with soil is a commercially available gravity retaining wall system described in Appendix A. It is precast and quickly constructed. It can also be fairly quickly removed when no longer needed. It is believed this would be more economical than a heavily reinforced concrete barrier wall.

Figure 21 shows a simple massive precast concrete DOUBLEWALL filled with soil which could absorb both vehicle impact and explosion. This could be used when only 10 or 12 ft of separation distance is available. For an explosion barrier, the precast concrete DOUBLEWALL would require more reinforcement than now used when it is a retaining wall.

## SUMMARY AND CONCLUSIONS

We believe that highway safety researchers familiar with the dynamic

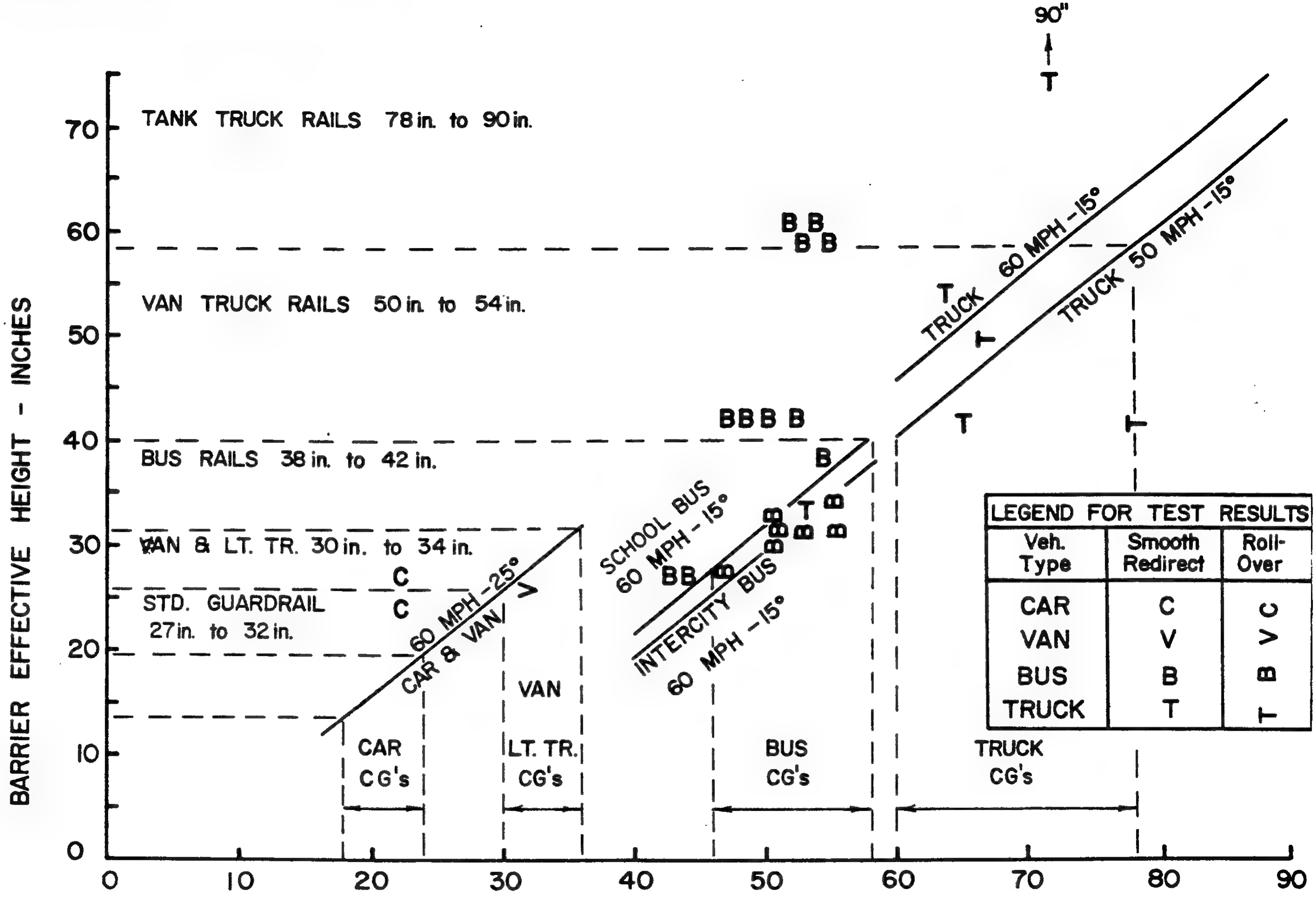


FIGURE 14. COMPARISON OF REQUIRED BARRIER HEIGHT TO VEHICLE CENTER OF GRAVITY—THEORY AND TEST RESULTS

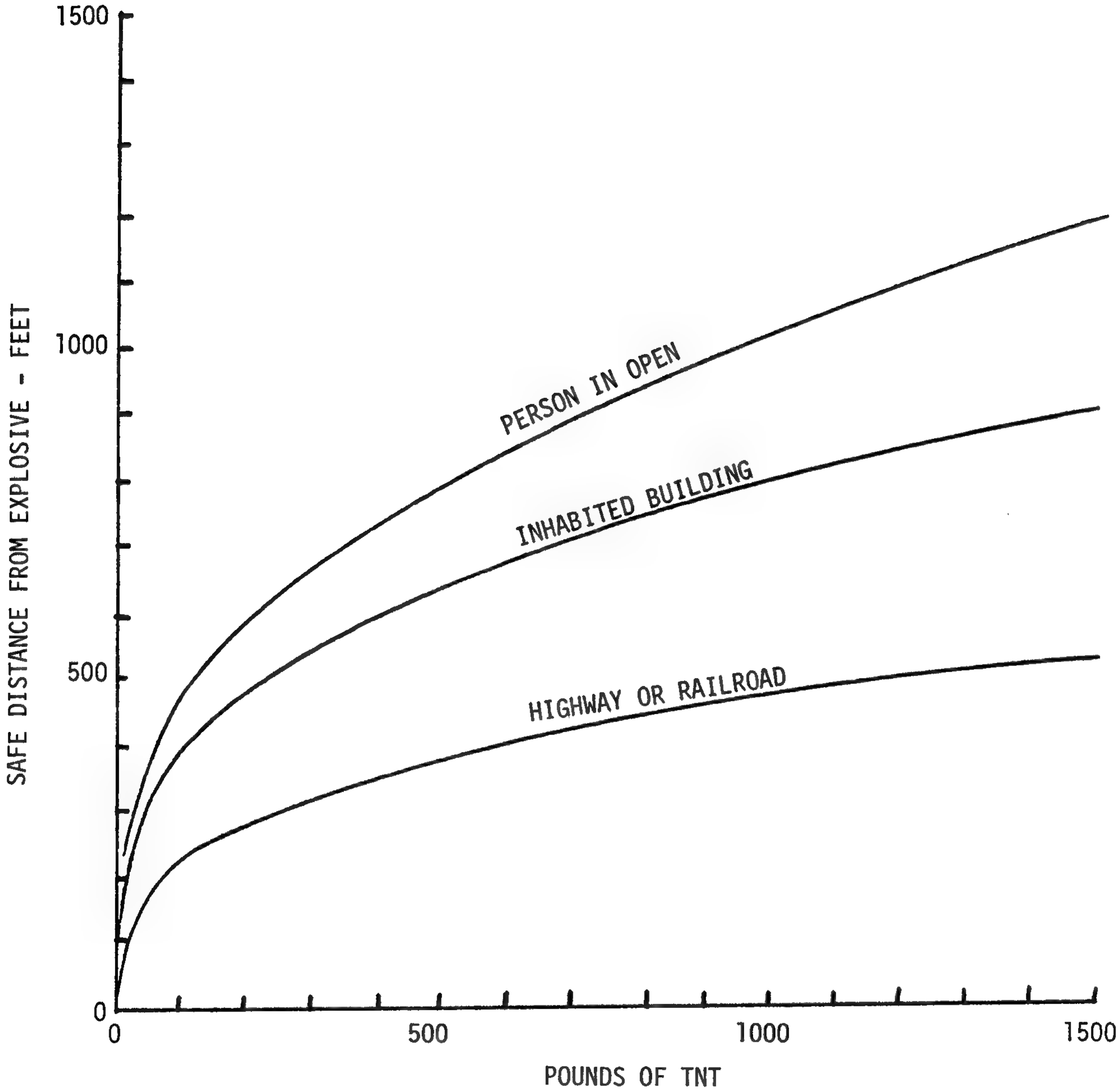


FIGURE 15. SAFE DISTANCE FROM EXPLOSION - NO BARRICADE
(from Ref. 26)

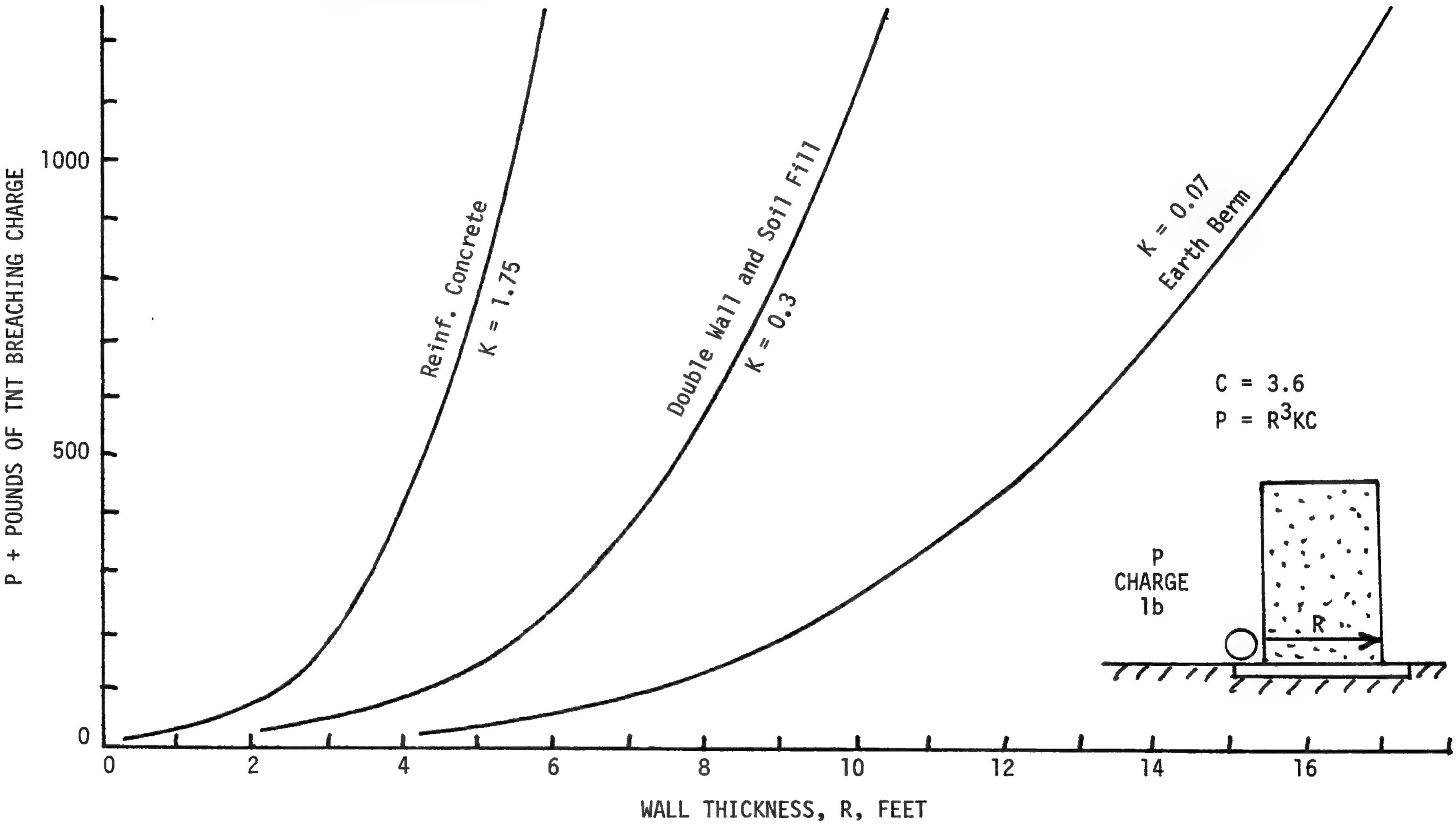


FIGURE 16. BARRICADE WALL THICKNESS TO RESIST BREACHING CHARGE
(from Ref. 26)

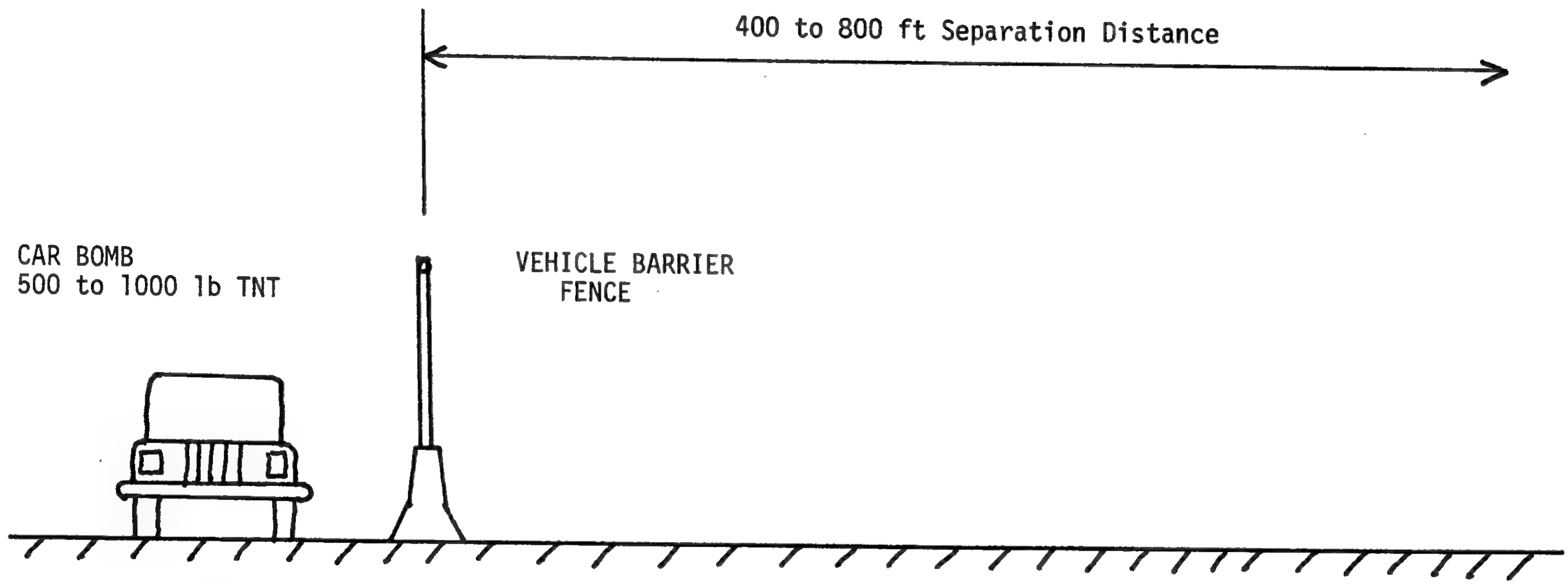


FIGURE 17. SIMPLE VEHICLE-BARRIER FENCE

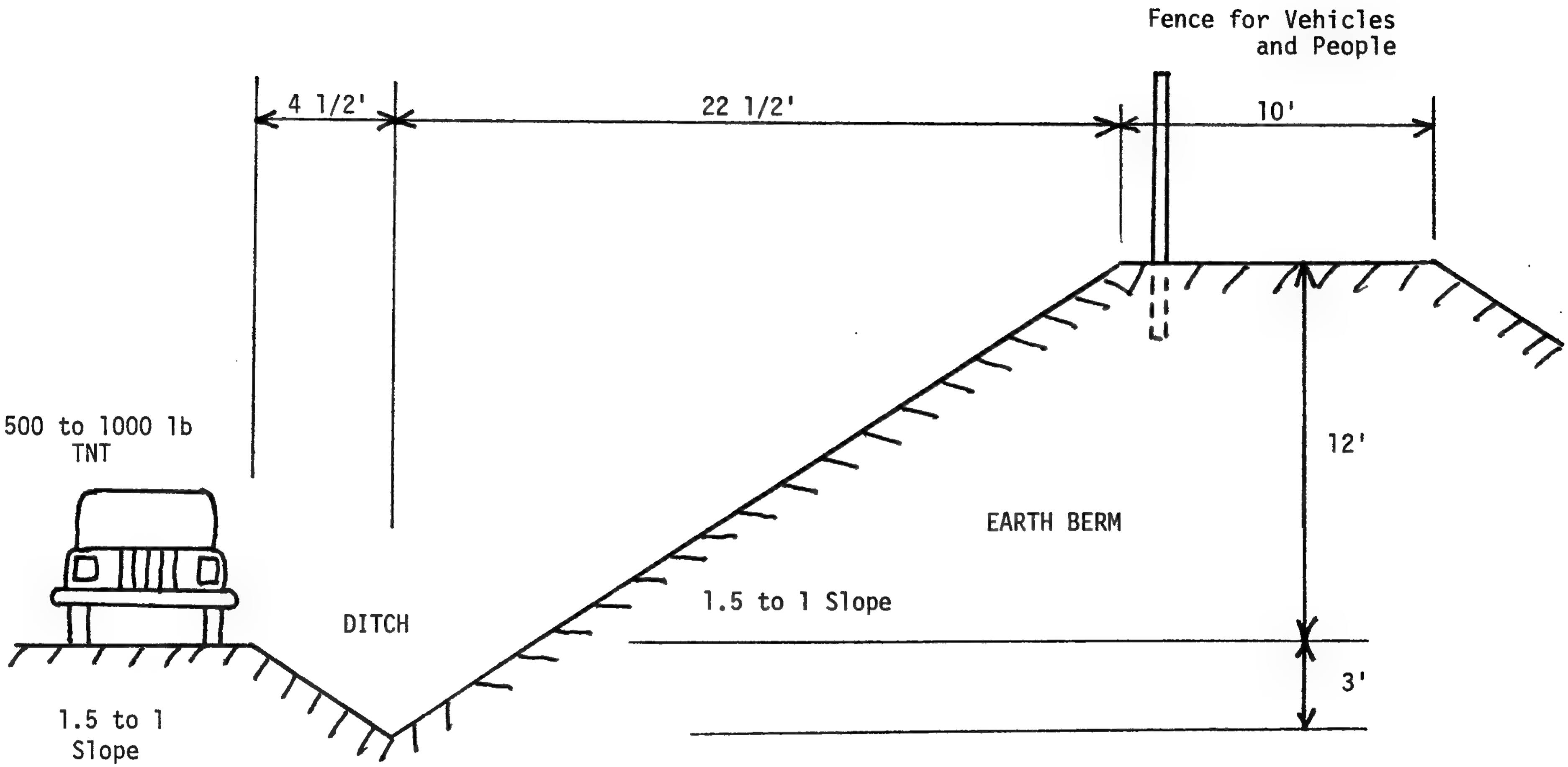


FIGURE 18. COMBINATION DITCH, EARTH BERM AND FENCE BARRIER



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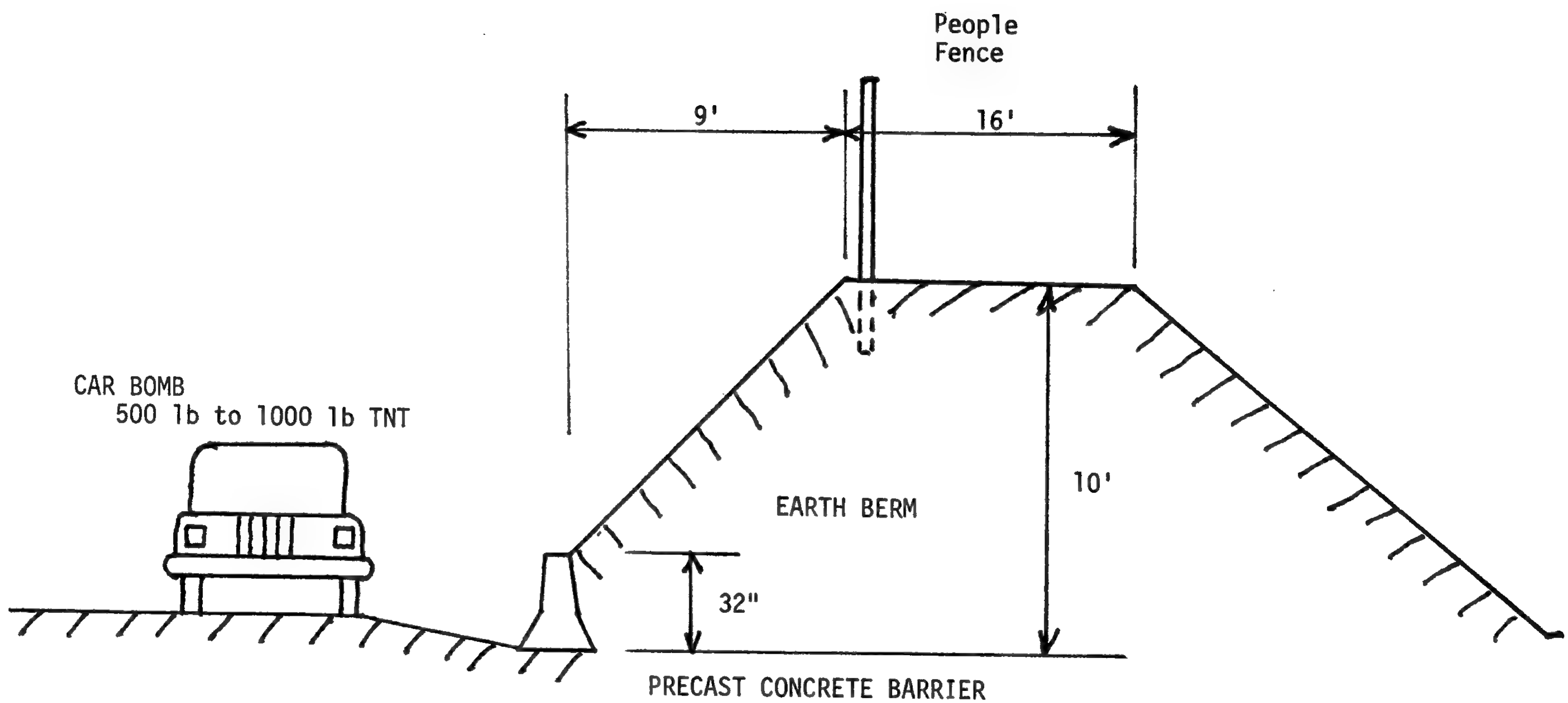


FIGURE 19. COMBINATION CONCRETE BARRIER AND EARTH BERM BARRIER



000380

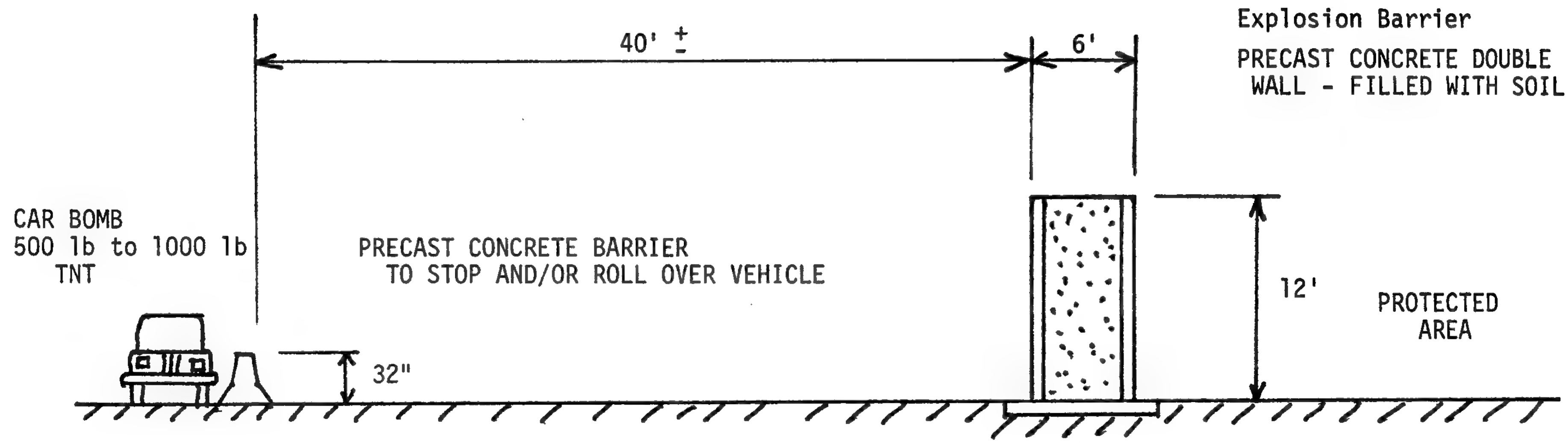


FIGURE 20. COMBINATION TRAFFIC BARRIER AND CONCRETE DOUBLE WALL EXPLOSION BARRIER

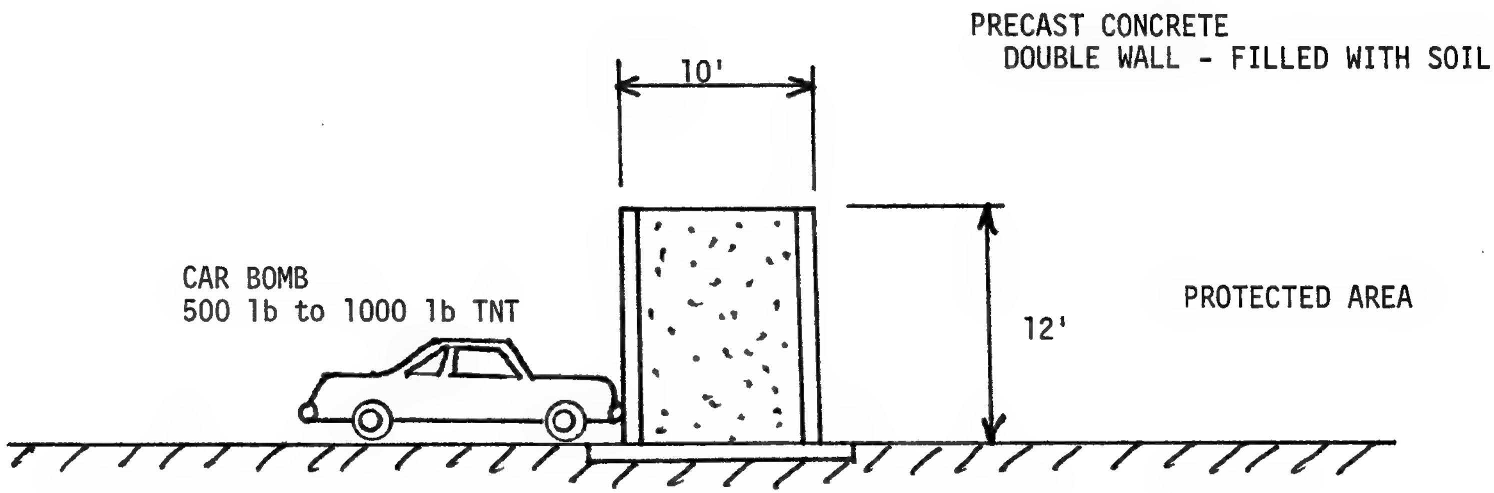


FIGURE 21. CONCRETE AND SOIL BARRIER

behavior of motor vehicles impacting barriers and traversing soil embankments could develop attractive economical barriers to resist car-bomb attacks. The required strength and height of these barriers are now well understood. The Texas Transportation Institute has available the personnel and facilities to design, build and conduct full-scale tests of such barriers. We have available a four square mile, 2400 acre, Bryan Air Force Base (deactivated) to conduct such tests.

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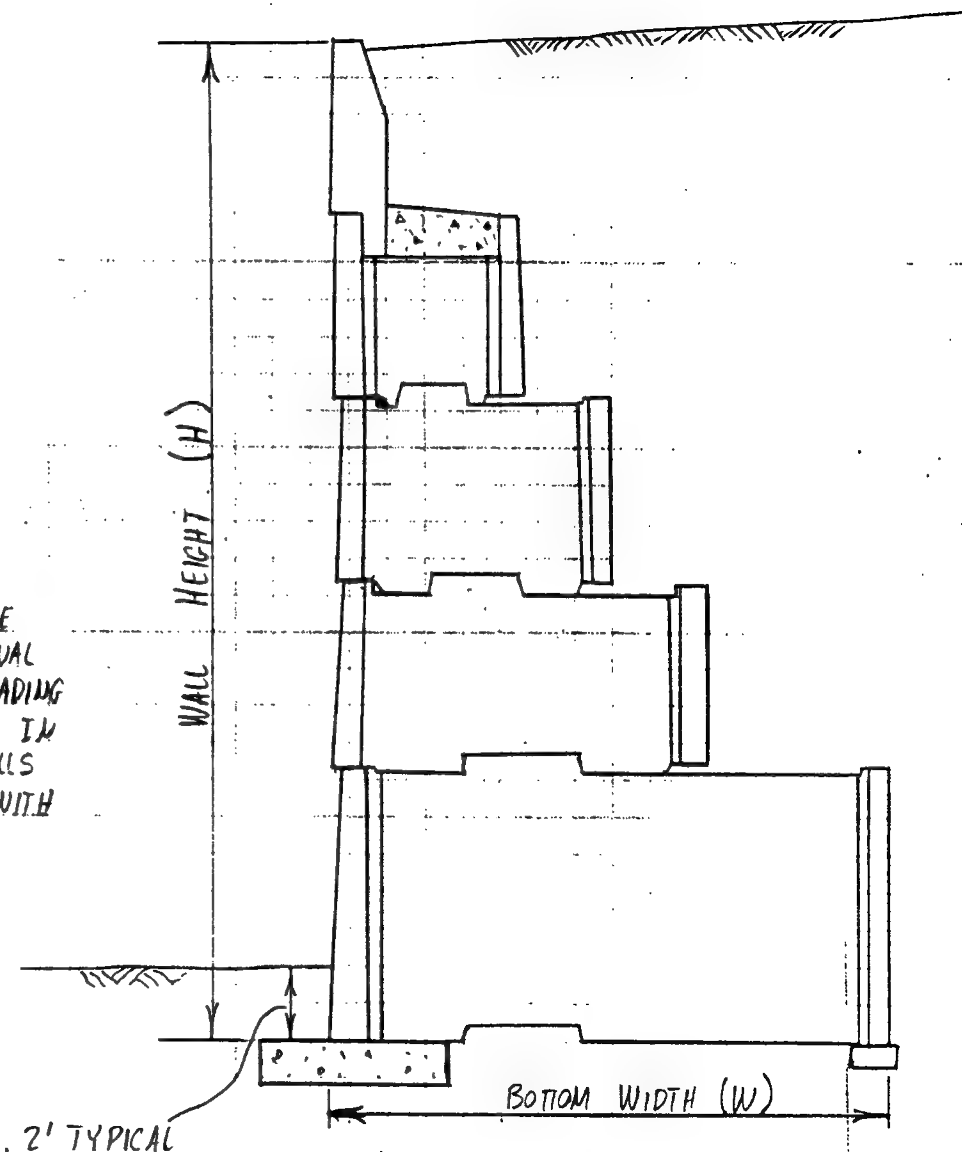
Form 1284A

**TEXAS SDHPT — BRIDGE DIVISION**

County ........ Highway ........ Design MPM Date 3/3/86
C-S-J ........ Ck Dsn ........ Date ........
Structure ........
Design for WIDTH VS. HEIGHT ON DOUBLEWAL RET. WALLS Sheet ........ of ........

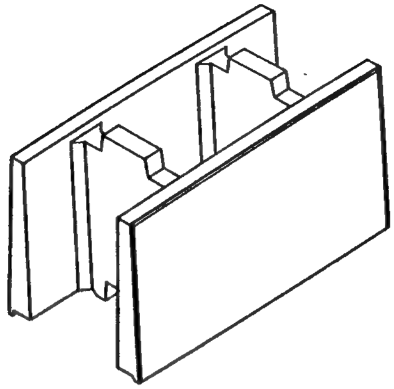
| WALL HEIGHT (H) | BOTTOM WIDTH (W) |
|---|---|
| 0'- 4' | 4' |
| 4'- 10' | 6' |
| 9'- 16' | 8' |
| 15' - 21' | 10' |
| 20' - 25' | 12' |
| 24'- 29' | 14' |

NOTE: THE ABOVE TABLE IS INTENDED AS A GUIDE ONLY. RETAINING WALLS ARE DESIGNED ON AN INDIVIDUAL BASIS. A VARIETY OF LOADING CONDITIONS CAN RESULT IN DOUBLEWAL RETAINING WALLS WHICH DO NOT AGREE WITH THE TABLE.



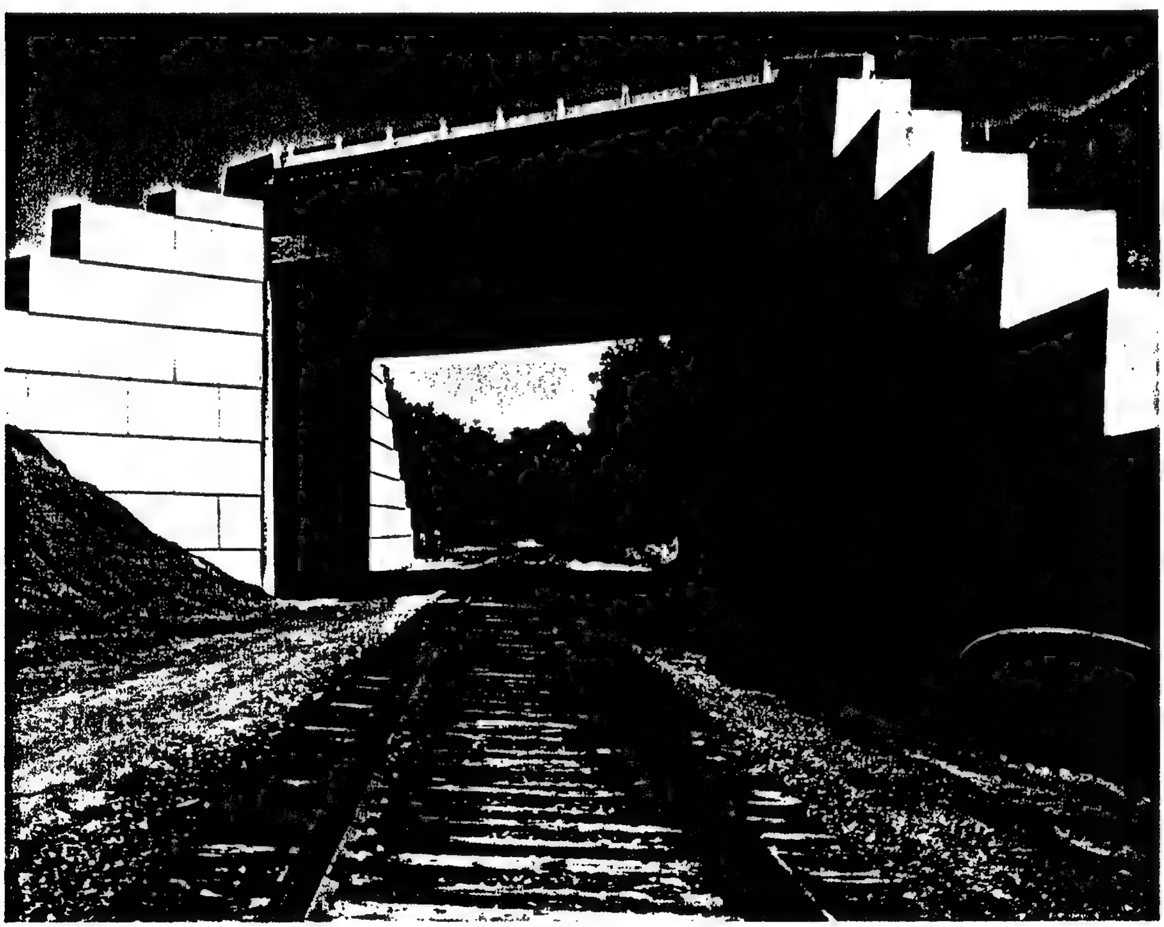

APPENDIX A - DOUBLEWALL PRECAST CONCRETE WALL FILLED WITH SOIL - DESIGN DATA (Ref. 28)

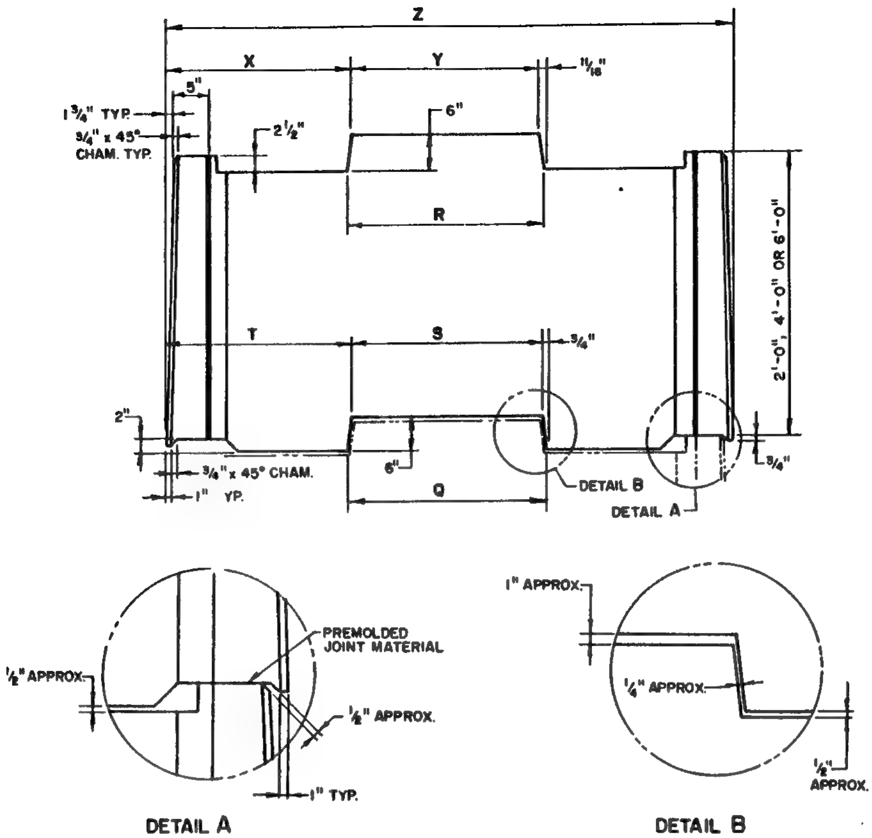
# Introduction



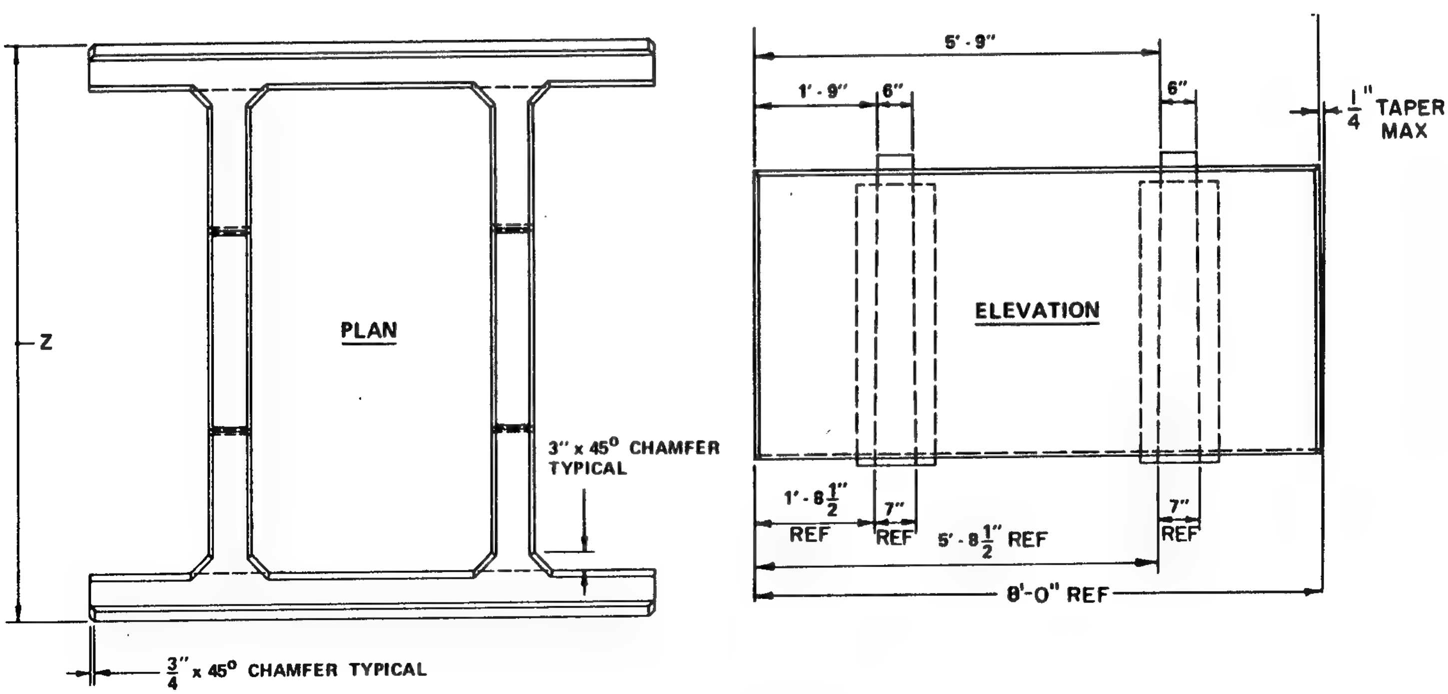
Doublewal is a recently developed gravity retaining wall system. This system consists of precast, interlocking, reinforced concrete modules which vary in size depending upon the application. Each module consists of two face panels held rigid and apart by connecting beams. Once in place without the use of fasteners, the units are backfilled with earth material to readily form an economical gravity retaining wall.

RETAINING WALLS
HIGHWAY AND RAILROAD IMPROVEMENTS






NOMINAL DIMENSION MODULE




NOMINAL DIMENSIONS

# VEHICLE ACCESS CONTROL AS RELATED TO COUNTERMEASURES AGAINST HIGH SPEED CAR-BOMB ATTACK

by

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Vehicle Access Control as Related to
Countermeasures Against High-Speed Car-Bomb Attack

## Introduction

During the period January 1, 1980 thru March 1, 1986, there were thirteen car-bomb attacks against overseas U.S. Government facilities or personnel. In four of these attacks, the weapon of choice was a moving vehicle laden with explosives. The drivers of these vehicles were prepared to sacrifice their lives in order to strike their blow against the enemy, the U.S. Government.

Prior to these events, barriers used in most vehicle access control systems were not designed to resist a deliberate high-speed ramming attack by a driver who was ready to sacrifice his vehicle and himself in accomplishment of his mission.

From an examination of the design and construction of the majority of "vehicle barriers" in place at the onset of this new threat, it would appear that they were designed on the assumption that no one would willingly risk personal injury or damage to their vehicle as the price they would have to pay for an unauthorized entry. That may well have been a valid assumption for the facilities located in the Continental United States during peacetime. But, it is obviously not a valid basis for the design of barriers used to protect critical facilities in todays overseas environment of subnational conflict.

A second assumption, which also has ceased to be valid, is that the presence of an armed guard can be relied on to turn away an attacker.

## Who Are We Defending Against?

In order to prepare a defense against an enemy we must first know something about him. The "terrorist" is frequently represented in the press to be a wild-eyed, unshaven, illiterate native of the Middle East, who has been given some minimal weapons instruction and turned loose.

If one reads the literature on terrorists and terrorism it is soon apparent that the Soviets, the Soviet Bloc Nations and their surrogates have established a wide spread network of training camps and technical schools specifically for the training of terrorists. The "formal" education of a terrorist, depending on his mission and abilities may range from three months to three years. The graduates of these training centers are the ones of most direct concern to us, and they are formidable foes. We must accept and understand this if we are to be effective in defending against them. They are:

a. Intelligent

b. Educated

c. Well-trained

d. Well financed

e. Well supported

f. Dedicated

g. Motivated, and

h. Willing to die for their cause

This is the enemy we are dealing with.

Factors Influencing a System

Second preface to my technical discussion is that each vehicular access control system and set of countermeasures must be devised for each site based on a variety of site-specific parameters. They include, but are not limited to:

a. The threat

b. The traffic volume

c. The traffic mix

d. The sensitivity/criticality of the site

e. The terrain

f. The space available

g. The natural environment

h. The "social" environment

i. The manpower available

j. The jurisdictional environment

k. The budget

Until recently, very few vehicle access control systems were designed to provide any real protection or countermeasures against a vehicle being driven with the intent to forcibly enter an installation. People just didn't do that sort of thing. And if they did, the guard's trusty pistol would surely take care of the problem. Recent history has demonstrated that small arms fire from the guard force cannot be relied on to abort a car bomb attack carried out by a dedicated adversary.

The Black & Veatch Study, on access points for Army installations has provided some insight into the functions and functioning of a vehicle access control system. The ideal, generic system should look something like the layout shown in Figure 1.

The normal function of a vehicle access control system is to enforce the site specific access policy of the installation management. This may range from an open base policy where all vehicles are waved through the check point to a very restrictive policy at a highly sensitive installation where a complete search is made of all persons and vehicles entering the premises.

A vehicle access control system with an anti-car bomb function has added features designed to assist in the identification of a threat vehicle and, then to deter, delay and hopefully to deny access to such a vehicle or vehicles. Additionally, the system should be designed to minimize injuries to personnel or damage to critical facilities should the bomb detonate.

The following descriptive material has been extracted (and somewhat modified) from the Black & Veatch report "Definitive Design Analysis of Access Points to U.S. Army Installations" prepared for the U.S. Army Engineer Division, Huntsville, Alabama.

## General Concept

The concept shown in Figure 1 is subdivided into zones. Each zone has its own function. Beginning at the public road, these zones include an approach zone, the actual checkpoint, a blast zone, and a safety zone. In addition, various elements support these zones. These includes traffic control devices, gatehouses, static barriers, active vehicle barriers, countermeasures and blast barriers.

## Approach Zone

The approach zone lies between the public road and the checkpoint. It is the section of road that vehicles must traverse before coming to the actual checkpoint. This section of road is used for the following purposes.

a. To modify the speed of incoming vehicles so they are traveling at the proper speed when they reach the checkpoint.

b. To sort traffic by vehicle type so trucks and visitors have the opportunity to move into the proper lane before reaching the checkpoint.

c. To provide stacking space for vehicles waiting to pass through the checkpoint, especially during the morning rush hour.

d. To provide the guards at the checkpoint an early opportunity to identify threatening vehicles, including vehicles trying to enter the base through the lanes designated for departing traffic.

Various traffic control devices may be used to support these purposes. Speed and direction sensing devices may be used to detect vehicles traveling at excessive speeds, and vehicles trying to enter the base through the lanes reserved for departing traffic. Traffic friction

devices may be used to reduce the speed of vehicles. Signs, lights, and other warning devices may be used to notify drivers of the upcoming checkpoint and to request them to follow specified procedures on speed and lane use. Static barriers may be used to limit the travel of incoming vehicles.

Atomated laser license plate readers could be used to detect unauthorized vehicles attempting to enter thru lanes designated for authorized vehicles only.

The length of the approach zone will vary due to the land available, the speed of incoming vehicles, the amount of weaving required to sort out incoming traffic, and the means used to control the speed of incoming traffic. The length of this zone and the volume of traffic will determine the number of lanes required to provide adequate stacking room to minimize congestion in the public intersection.

<u>Checkpoint</u>

The checkpoint is the main controlling or security checking element of an access point. The checkpoint includes the gatehouses for the security force, the pavement to carry the various traffic patterns, and the devices necesssary to support the work of the security force. The checkpoint must accommodate the following traffic patterns.

a. Incoming automobiles occupied by military personnel holding proper passes.

b. Visitors requesting information or access to the installation.

c. Military convoys including large tanks.

d. Delivery vans, trucks, and buses driven by civilian personnel that may require a complete search.

e. Vehicles given access to the installation.

f. Vehicles denied access.

g. Vehicles coming from the installation to serve as escorts for visitors.

h. All of the above vehicles as they depart the installation.

The checkpoint will require one or more buildings to shelter the security force. These buildings may include the following:

a. Traffic Check Post, used to house one or two guards at the left of single or double lanes of traffic.

b. Visitor Control Center, used to house additional guards who will oversee the entire checkpost, monitor security equipment, and check visitors and incoming trucks.

c. Elevated Control Tower, used to increase overall surveillance of the complete access point, especially in areas of rugged terrain.

The checkpoint must support at least three levels of operation including the following:

a. Open Base or Minimal Control. At this level, the checkpoint is used only to observe the flow of traffic. The incoming traffic would be waved on without any check of identification. Outgoing traffic would also pass freely through the checkpoint.

b. Limited Vehicle/Personnel Check. At this level, the Visitor Control Center is used to observe the flow of traffic and the operation of the guards. Individual guards would be posted in each lane of traffic to check the identification of each incoming vehicle and/or the persons within the vehicles. Outgoing traffic would either be checked in a similar manner or be allowed to pass freely.

c. Complete Vehicle Search. As with the previous level, the visitor control center is used to observe the flow of taffic and the operation of the guards. Two or more guards would be posted in each traffic control post, and guards would be placed in each lane of traffic to search incoming vehicles and/or the personnel within the vehicles. Traffic in the outgoing lanes of traffic may or may not be limited by vehicle barricades.

Blast Zone

The blast zone lies between the checkpoint and the barrier/countermeasures area. It includes the roadways between the checkpoint and vehicle barricades, and the static barriers along these roadways. The blast zone provides distance between the guards at the checkpoint and the vehicle

barricades and countermeasures area where a threatening vehicle may be finally stopped. This distance provides time to operate the vehicle barricades and countermeasures and some protection for the guards if that vehicle explodes at the barricades. The length of this zone is a compromise between three factors.

a. Vehicle barricade operating time

b. Blast separation distance

c. Effective guard control

The vehicle barricades used to block vehicular traffic may be either normally deployed or normally open. If they are normally deployed, a barricade must be opened for each vehicle admitted to the base. This operation will be slow, permitting four to fifteen vehicles to pass each barricade per minute. Where the blast zone and/or approach zones are very short, this operation may be necessary. However, where enough distance is available, leaving the barricade open will permit a greater volume of traffic to flow through the access point. If the barricades are normally open, the guards must have time to recognize a threatening situation and react, and the barricades must have time to be deployed before the threatening vehicle reaches it.

If the threatening vehicle explodes at the barricade, the explosive will generate a blast overpressure and flying debris and fragments. These effects will diminish over distance. Therefore, greater distances in the blast zone result in greater safety for the guards at the checkpoint. This distance is determined by the assumed weight of the explosive charge in the postulated "threat Vehicle."

The guards at the checkpoint need to be able to have control over the area at the vehicle barricades. They need to be able, by direct line of sight or closed circuit television to see the barricades in order to verify their status and to see what people are doing to the barricade if they stop and get out of their vehicle. The guards also need to be able to shoot or employ other countermeasures against intruders stopped at the barricade. Greater distances to the blast zone make these actions more difficult.

Static barriers and traffic channeling systems must be used along the road in the blast zone to keep all vehicles on the main road until they clear the vehicle barricades. The blast zone and/or the vehicle barrier countermeasure area can in effect function as a sally port. If a vehicle is allowed into this zone by the guards, the static barriers and vehicle barricades are used to entrap the terrorists. The static barriers are used to confine the terrorists to the roadways, and the vehicle barricades to close off the end of the blast zone.

For an explosion of 10,000 pounds of TNT, the blast zone should be 390 feet long to provide minimal protection for the guards. A vehicle traveling 60 miles per hour or 88 feet per second will cover this distance in 4 1/2 seconds. This time should be adequate for the guards to react and for the faster barricades to be deployed. This distance of 390 feet would not be excessive for the guards to control. If this distance cannot be achieved at a given site, the layout must be modified in two respects.

a. Blast barriers should be used between the checkpoint and the vehicle barricade.

b. The vehicle barricade should be deployed at all times.

Vehicle barricades must be used in the outgoing or departing traffic lanes as well as in the incoming lanes. Otherwise, terrorists could use these lanes to gain entry to the base.

Functions of the Barrier/Countermeasure Area

a. Positively stop an intruding vehicle

b. Entrap an intruding vehicle

c. Permit application of appropriate countermeasures

d. Mitigate blast damage to nearby areas

## Safety Zone

The safety zone completely surrounds the vehicle barrier/countermeasures area, the assumed location where a terrorist vehicle will explode. This zone is the distance from the vehicle barricades to any inhabited buildings, public roads, or outdooe recreation areas. This distance extends in all directions to protect base personnel from an explosion at the vehicle barricade. The distance is determined by the postulated weight of the explosive charge and the character and location of the facility or personnel to be protected. For an explosion of 10,000 pounds of TNT, the blast zone should be a minimum 865 feet in radius. If adequate distance is not available, it may be necessary to provide blast barriers to protect facilities against the effects of a blast.

## Typical Existing Facility

Now that we have examined the general makeup of an idealized vehicle access control system, lets look at a "typical" existing facility, designed about forty years ago when terrorists were not a consideration. Figure 2 shows this hypothetical installation. The manager of our "typical" facility, in response to his concern and perception of the threat and has "hardened" the installation by the addition of a hydraulically operated "rising step" barrier in the entrance lane and a tire shredder device in the exit lane. He has also armed the guards with .38 caliber revolvers.

In front of the facility there is a public highway. The front boundary of the installation is protected by an eight foot concrete wall topped with barbed wire aand there is a guard house manned around the clock by two armed guards.

The sides and rear of the compound are protected by a chain link fence built to DoD security specifications and the two, little used vehicle access roads on the sides, are protected by DoD specificed chain link gates which are fastened with an approved chain and padlock. The railroad spur line is also similarly closed off. Our hypothetical base manager now feels that his is safe from a car bomb attack.

Based on past experience we know that typical terrorist attackers will have reconnoitered the installation and will know exactly what security measures and barriers are in place. Some of their options are:

a. Equip their vehicle with special tires that will permit them to drive down the public highway, enter through the exit lane, drive over the tire shredders and continue right to the front door of the facility.

b. Drive across the field on either side, ram through the chain link fence and drive to the building.

c. Ram through any one of the three chain link gates and drive to the building.

Knowing the shooting ability of the average guard with a revolver, I'm reasonably sure that the driver would, after driving the bomb to his target, still be able to set his short delay fuse and run out of the area unharmed.

From this example, which unfortunately is representative of many of our installations, it is immediately apparent that one of the first requirements for controlling penetration by vehicles into sensitive areas is to harden <u>all</u> potential entry points, eliminate unnecessary ones, and to harden the entire perimeter so that vehicles may enter only at designated, secure, controlled entry points.

A second requirement for some sensitive facilities, is to confine "outside" vehicles to specific areas of the base after they have been screened and to keep them on secure roadways which have side barricades that will prevent them from leaving their authorized routes.

Figure 3 illustrates one such channeling option for forcing vehicles to stay on prescribed roadways using 24-inch or higher concrete curbs.

A minimum width, one lane traffic channel, not only keeps outside vehicles from having free run of a compound, but also serves to slow them down because of the close clearances.

In retrofit installations where there are long straight stretches of roadway, it may be desirable to enforce low rates of speed by placing obstacles in the road to force vehicles to use a narrow "detour" route and as a result, cause them to slow down in order to drive around them. Figure 4 illustrates such a system using large blocks of concrete, stone filled cribs, large boulders or other available massive objects.

At a new installation, with sufficent space, there are a number of options available for vehicle speed control designs and passive countermeasures.

Figure 5 illustates the "Slalom Course", a narrow sinuous course enforced by the narrow traffic channel. The curves, ideally, should not be as regular in curvature or spacing as shown. Such a regular pattern makes it easy to negotiate the curves at a higher speed than would be possible with an irregular layout.

The "Section Corner" shown in Figure 6 is a narrow right angle turn. The inside corner has a large enough radius so that, when the bollards are removed or retracted a long wheelbase vehicle can negotiate the turns. In this case, a portion of the outside curb has been designed to break away on impact and allow a speeding vehicle to enter a deep pit or pond.

The reverse banked curve illustrated in Figure 7 resembles the section corner except that the curve is banked downward on the outside of the curve and speed bumps have been added.

Another passive countermeasure illustrated in Figure 8 is the "Low Bridge." This device is a massive overhead beam designed to just clear the top of a passenger car and to impact the windshield area of any vehicle higher than a small pickup truck. This is intended to enforce the requirement for all trucks and other high profile vehicles to separate from the passenger car traffic stream and use the designated lane and thus be forced to enter a secure inspection area.

It is essential that this device be suitably built and installed so that it will not be structurally damaged or "taken out" by a deliberate or accidental collision.

Now let us look at other ways and means of inhibiting or stopping a high speed vehicle penetration into a sensitive area.

## Ways and Means of Inhibiting High Speed Vehicle Attack

The speed with which a bomb laden vehicle can approach a gate or other target is a critical factor in its interception and neutralization. If we can deny high speed approach our probability of stopping a vehicle before it presents a serious hazard to our critical facilities is significantly increased. My discussion of ways and means of inhibiting high speed approach is based on the assumption that you do have the necessary space to do this.

This "brick wall" approach, shown in Figure 9 is one of the cleanest and simplest solutions to this problem. One simply surrounds the critical area or optionally, the visitor's parking area with a wall of sufficient height and strength to prevent ramming access by any threat vehicle. Portals are provided only for foot traffic and shuttle busses or other transport are provided to the visitor after he dismounts from his vehicle and walks thru the entry portal. This is a nice idea, though not practical in many cases.

Figure 10 illustrates the ultimate, simplistic, traditional approach which has been to "just blow them away." As history has demonstrated in several instances, this method has not been reliable in practice, and brings with it a number of other problems. These problems include those of where do all those bullets wind up that miss the target, or how many innocent bystanders are killed if one of our rounds detonates the bomb?

Passive Barrier Options

There are a number of passive (fixed) vehicle barriers available. These include, but are not limited to:

a. "Jersey bounce" concrete highway median barriers

b. Steel highway guard rails

c. Ditches

d. Berms

e. Fixed bollards

f. Concrete shapes

g. Walls

h. Massive boulders

i. Earth or rock filled barriers

However, in order to have the ability to selectively stop, or allow traffic to pass at prescribed points, it is necessary to have active barriers which can be operated either manually, automatically or on command. These barriers, in order to serve their mission in an anti-car bomb system, must be capable of stopping a speeding vehicle and still be immmediately reusable with a minimum of repairs.

Active Barrier Options

A number of active devices documented in the Black & Veatch report are typical of this family of barriers. Some of these are:

a. The Net. In the upper left portion of Figure 11 the net is shown in the storage position. In the center left illustration it is shown in the deployed or ready position and in the lower left, it is shown engaged by a vehicle which has been stopped after traveling fifty feet or so. The upper right illustration shows how a second net might be used as a back-up when very heavy vehicles are encountered. The component identified as an "energy absorbing device" acts as a brake and pays out a high-strength tape in order to gradually decelerate the vehicle. A net system designed for a specific weight vehicle can deceletate it, even from high speed, at a controlled rate such that neither the occupants nor the vehicle will be injured. There are several vendors of this type of system and they can be designed for any weight and velocity vehicle.

b. The "tire puncture" device shown in Figure 12, is typical of a number of products of this type. While this type of device will inhibit penetration by a driver more concerned about his tires than his mission, it will not stop a dedicated intruder equipped with the proper type of tires.

c. Figure 13 illustrates a vertically sliding "crash beam" which makes an effective barrier if, the beam is massive enough and the end supports are well buttressed on the side opposite the "attack" side. This system, and all others requiring underground support machinery are potentially vulnerable to problems related to environments with a severe freeze-thaw situation, heavy rainfall, high water tables or blowing fine sand.

d. Similarly, the horizontally sliding "crash beam" shown in Figure 14 can also provide an effective barrier when appropriately designed and constructed for the worse case threat. It has an advantage in areas where subsurface systems may have operational problems, in that all the machinery is above ground. One consideration in the location of such a system is that it requires a long "storage" area, adjacent to the mount that houses the drive mechanism, for storage of the beam when it is in the retracted or storage position.

There are several active barriers that rise up out of the pavement when in the deployed position. One of the simplest of these is the rising bollard shown in Figure 15. This consists of a large diameter (8 to 10-inch) heavy wall, concrete filled steel pipe which is raised and lowered, along it's long axis, by a hydraulic cylinder. The bollard is mounted in a massive reinforced concrete foundation that enables it to resist the forces of a high speed impact.

The most commonly seen in recent installations is the rising barrier, or "rising step" type shown in Figure 16. In this type of barrier, the movable component is a longitudinal segment of a cylinder, usually about a 45 to 60 degree segment. It rotates about the cylindrical axis and presents a curved surface on the attack side. Tests with a 15,000 pound truck, traveling at 50 miles per hour have demonstrated that properly designed and installed barriers of this type are effective.

There are several rising types of barriers which present inclined spear-like members or vertical blades to the attacker. Two versions of this type are shown in Figure 17.

One rather interesting concept, based on the ancient pit-type of animal trap is shown in Figure 18. In this case one end of the pit cover drops on command and forms a ramp for the on-coming vehicle. The ramp terminates in a solid concrete wall several feet high.

In addition to these well documented barriers, I would like to offer some original concepts for active countermeasures that are potentially lethal and which, therefore should be considered only if accompanied by suitable control measures that would prevent their accidental or premature operation. As a matter of fact, <u>any</u> type of barrier or countermeasure which can result in injury or death should be considered only after a full study of the legal and liability implications has been made.

The first concept illustrated in Figure 19 is that of a rapidly generated cloud of smoke or a mass of foam which is used to obscure an obstacle or an abrupt change of direction in the roadway.

Figure 20 illustrates the use of anti-personnel (anti-driver) agent dispensers or sprinklers which are positioned to spray the agent at windshield level. Possible agents might include:

a. White paint (to obstruct vision through the windwhield)

b. Tear gas

c. Ammonium hydroxide (concentrated household ammonia)

d. Gasoline (and an ignition source)

Figure 21 shows an overhead beam could be used to mount various types of comand-controlled countermeasures and dispensers such as:

a. A photoflash bomb (several million candlepower)

b. Pyrotechnic fireball projectors (aimed to impact on the windshield)

c. Laser projectors (sufficient power to permanently blind)

d. Automatic firing shotguns firing slugs at windshield level

Figure 22 shows an anti-friction agent being sprayed on a curve located so that a vehicle, on going out of control would run into a pit or pond.

Figure 23 shows an installation of command-armed mines located in roadway. A magnetic or other type of sensor would be used to control detonation in order to avoid premature firing.

Figure 24 shows command-armed Claymore mines installed in berms at roadside. The berms are a means to channalize the vehicle, contain the Claymore fragments and it mitigate blast damage if the bomb is detonated. A magnetic or other type of sensor would control detonation in order to prevent premature firing.

Figure 25 shows a command-armed overturning ramp which would overturn a vehicle into a pit or pond.

Figure 26 shows a command-armed "deflection" beam that would force a vehicle off the road and into a pit or pond.

As one can see, there are many options for barrriers and countermeasures that might be used to defeat a bomb-carrying vehicle. However, since there is always the distinct possibility that the barrier, a countermeasure or the driver might cause the bomb to detonate, all such installations should be installed with suitable earth berms designed to limit blast damage effects on nearby personnel or structures. A well designed and sited barrier or countermeasure gives one an opportunity to control just where the bomb detonates. Make the best of this opportunity.

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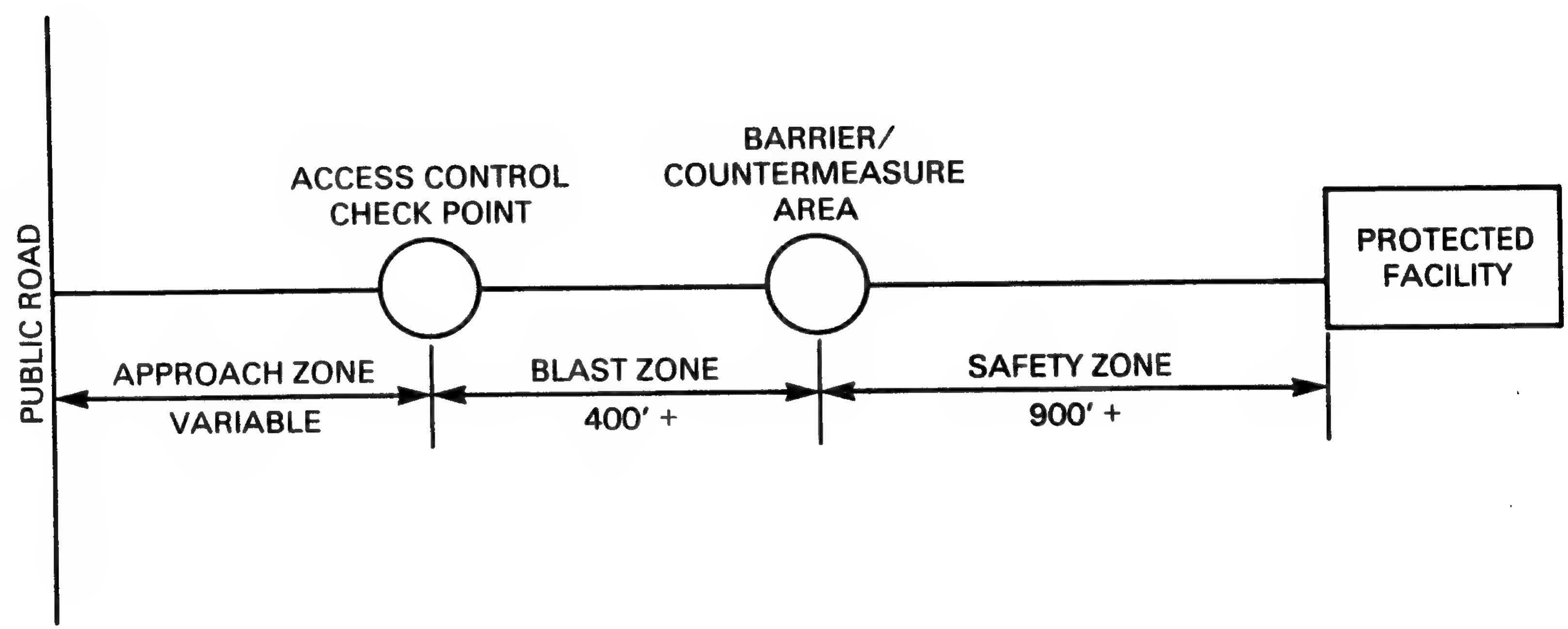


Figure 1. Vehicle access control system layout.

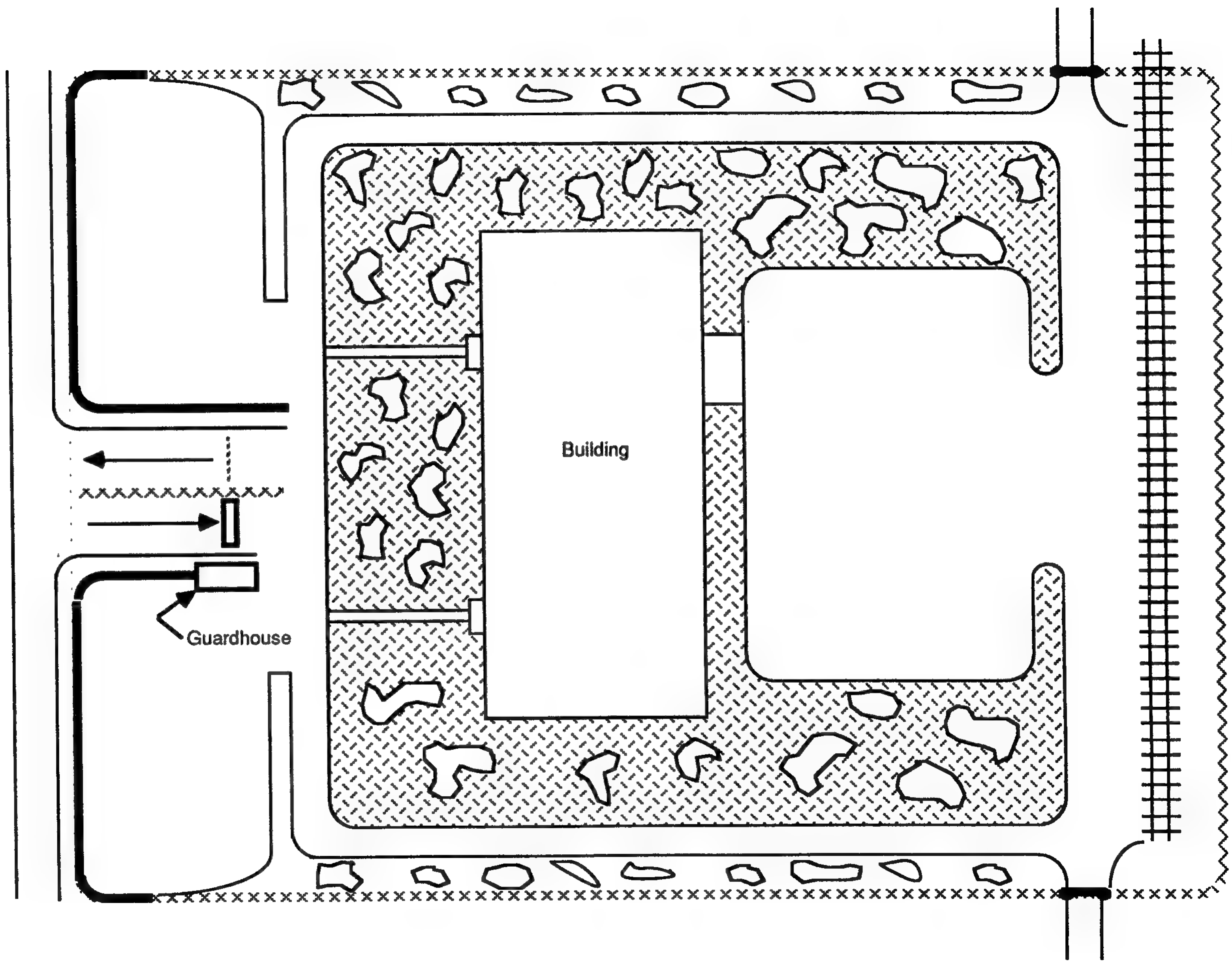


Figure 2. Typical facility layout.

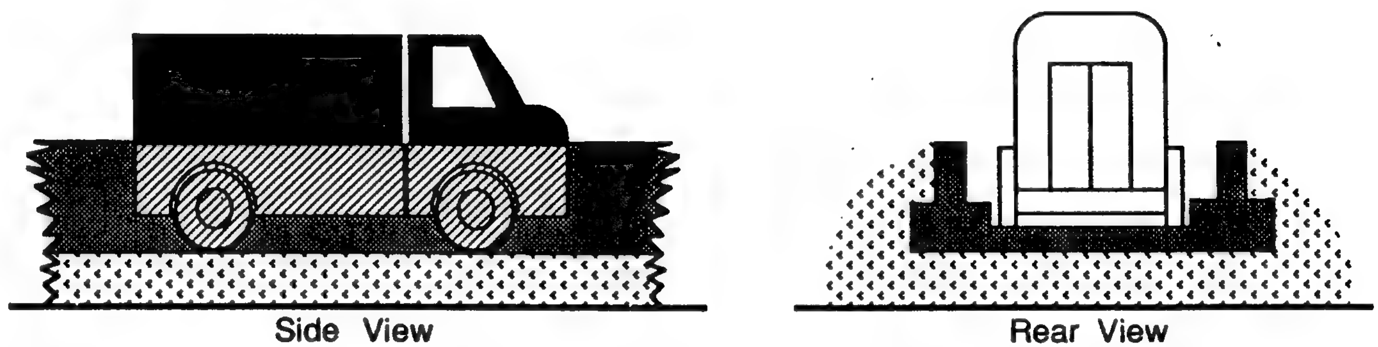


Figure 3. The "Traffic Channel".

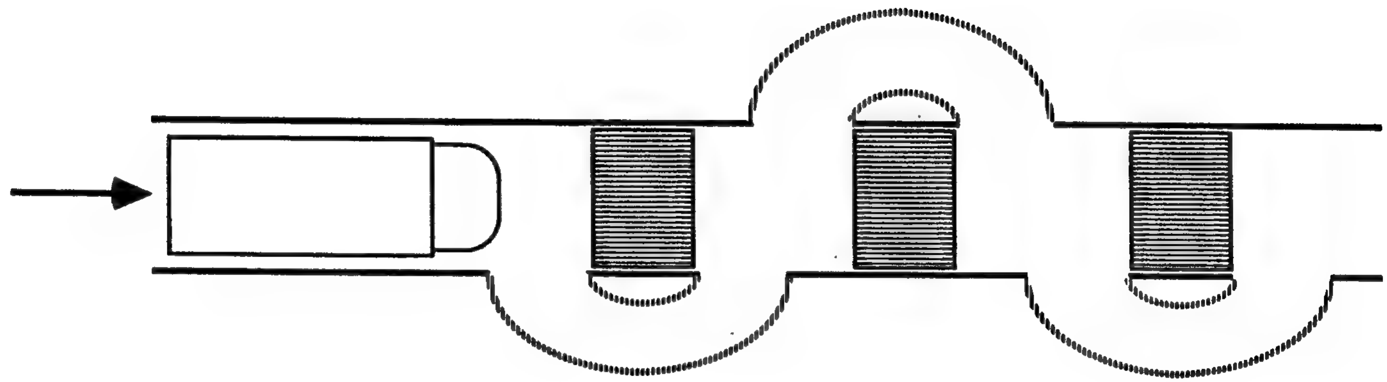

Figure 4. The "Obstacle Course".

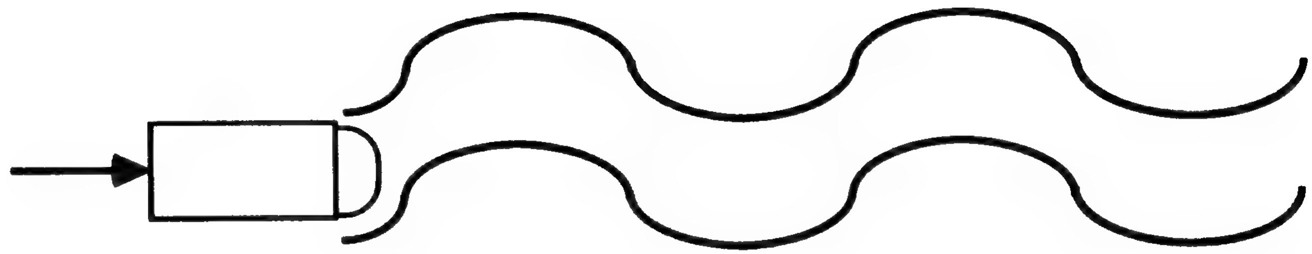

Figure 5. The "Slalom Course".

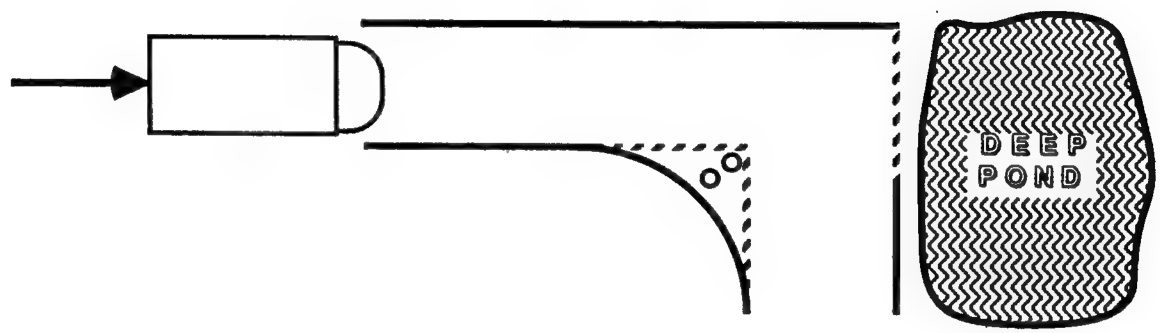


Figure 6. The "Section Corner".

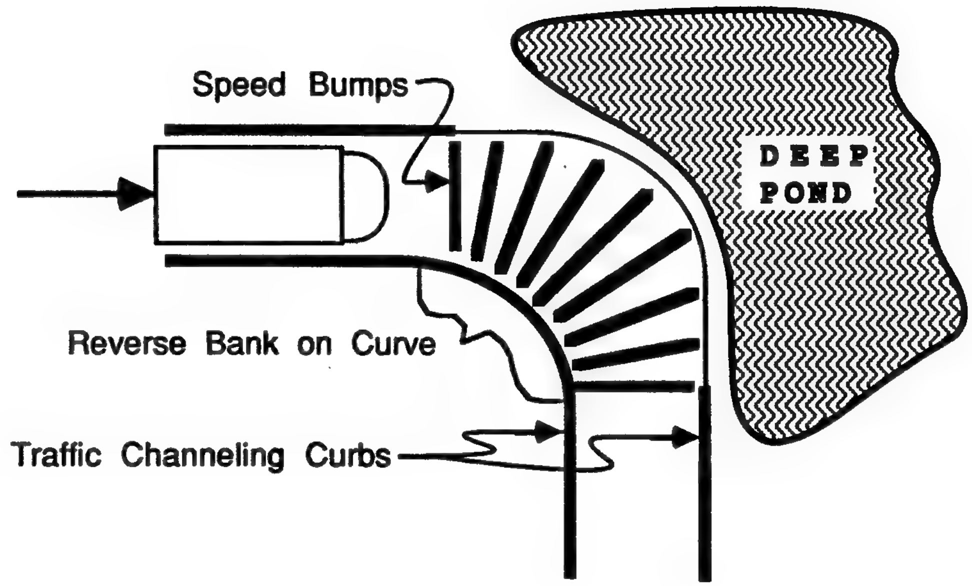


Figure 7. The reverse banked curve with closely spaced speed bumps.

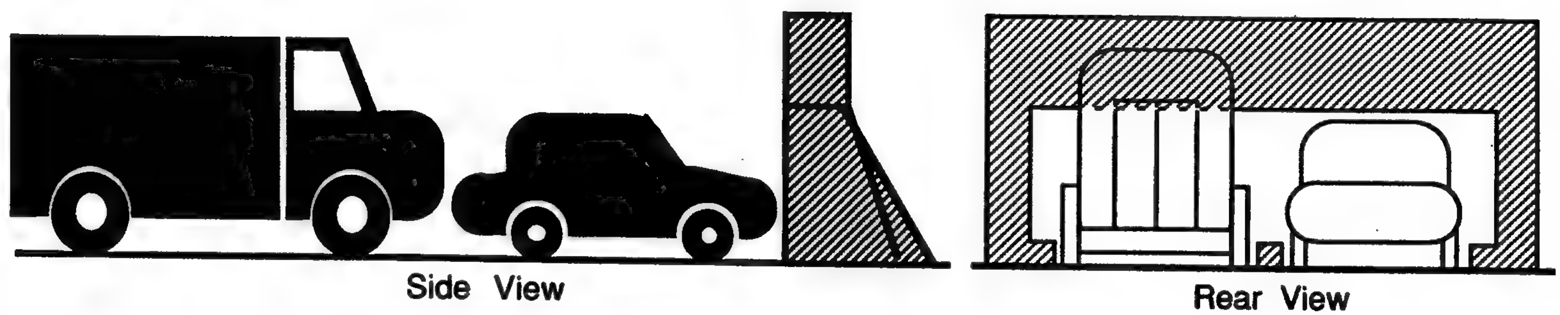


Figure 8. The "Low Bridge" traffic separator.


Figure 9. The "Brick Wall" approach.

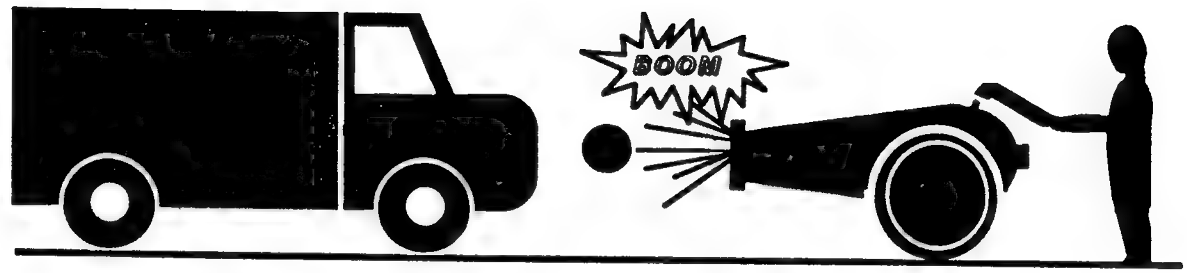


Figure 10. The "Shoot Out".

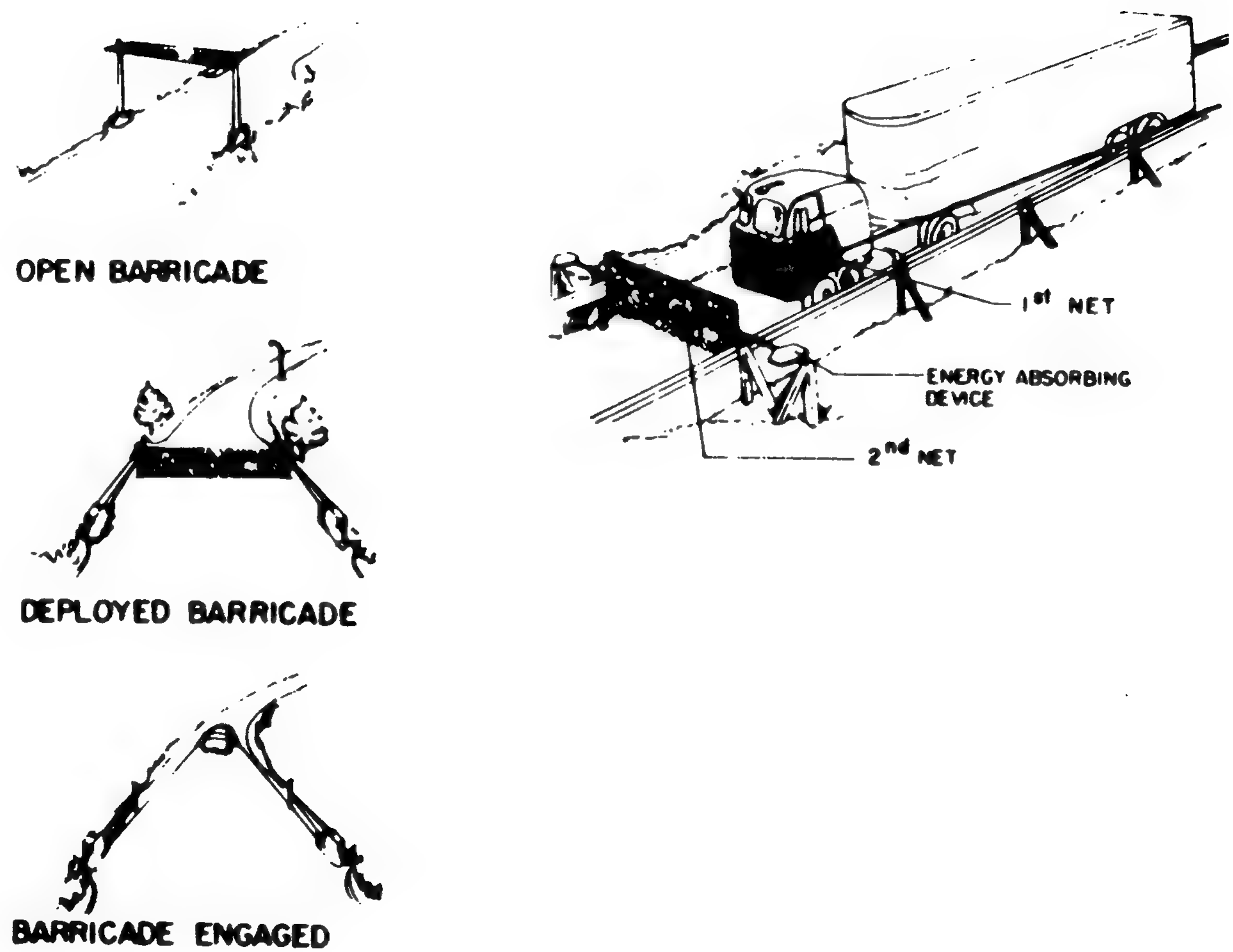


Figure 11. The Net.

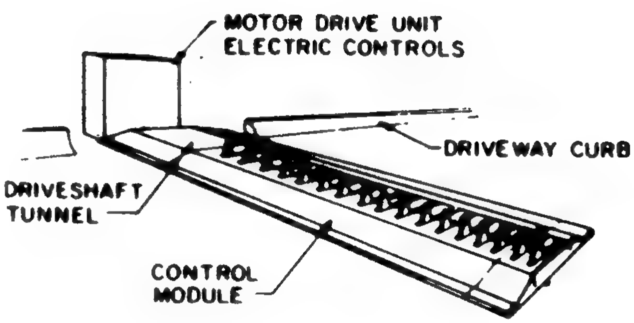


Figure 12.  A tire puncture device.

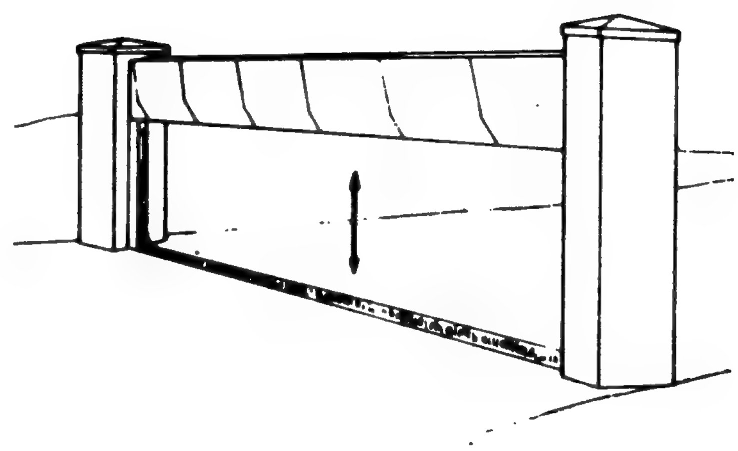

Figure 13.  Vertically traveling crash beam.

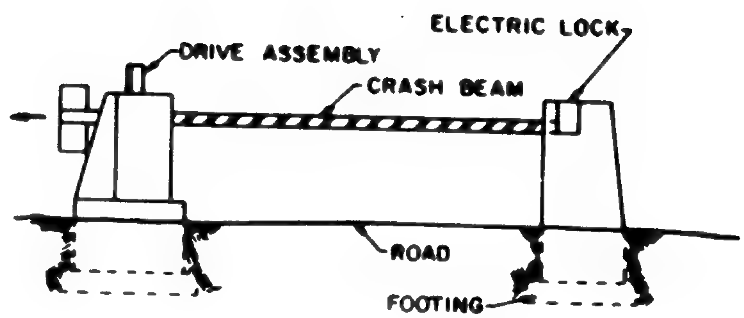


Figure 14. Horizontally traveling crash beam.

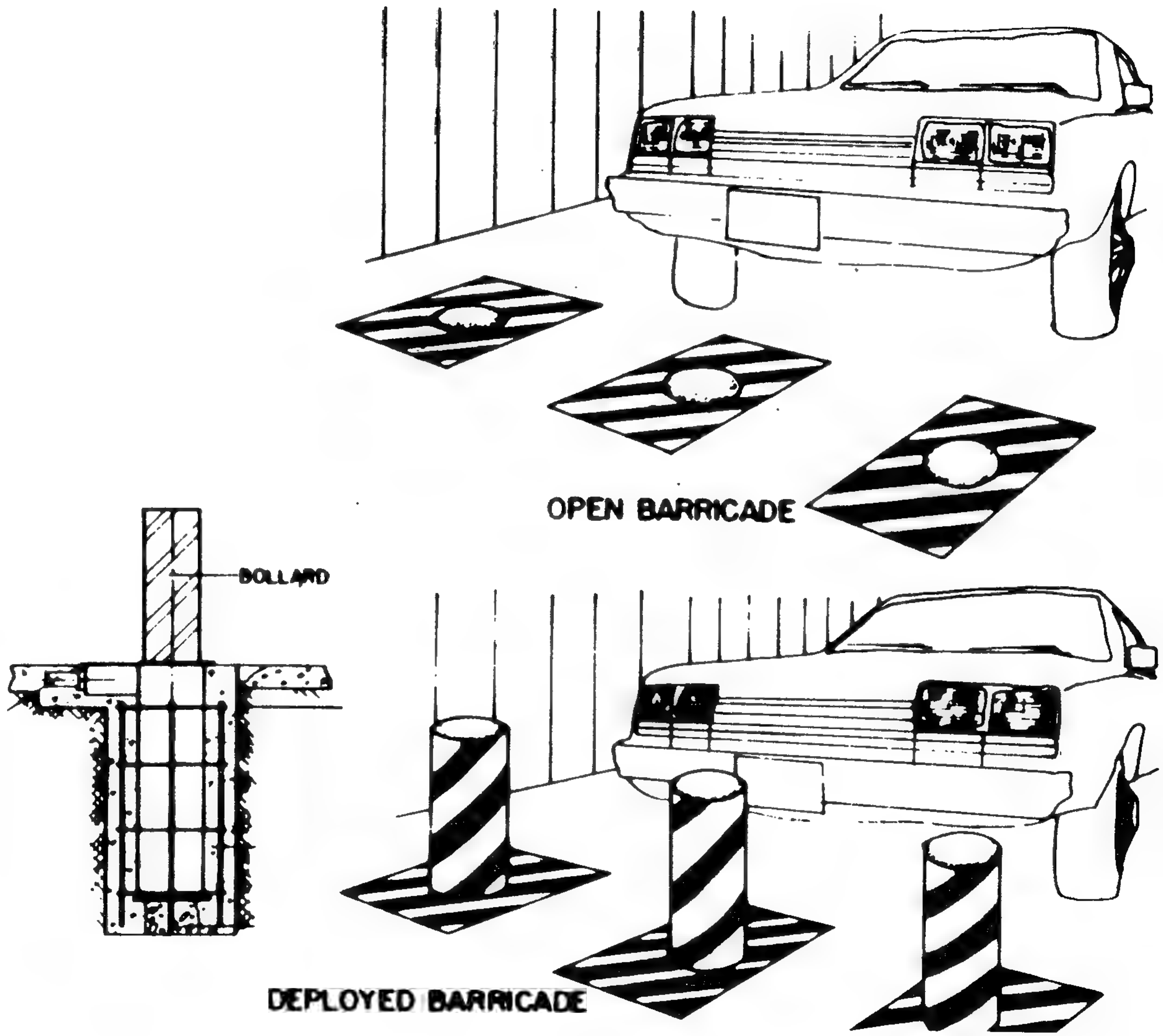


Figure 15. Rising bollards.

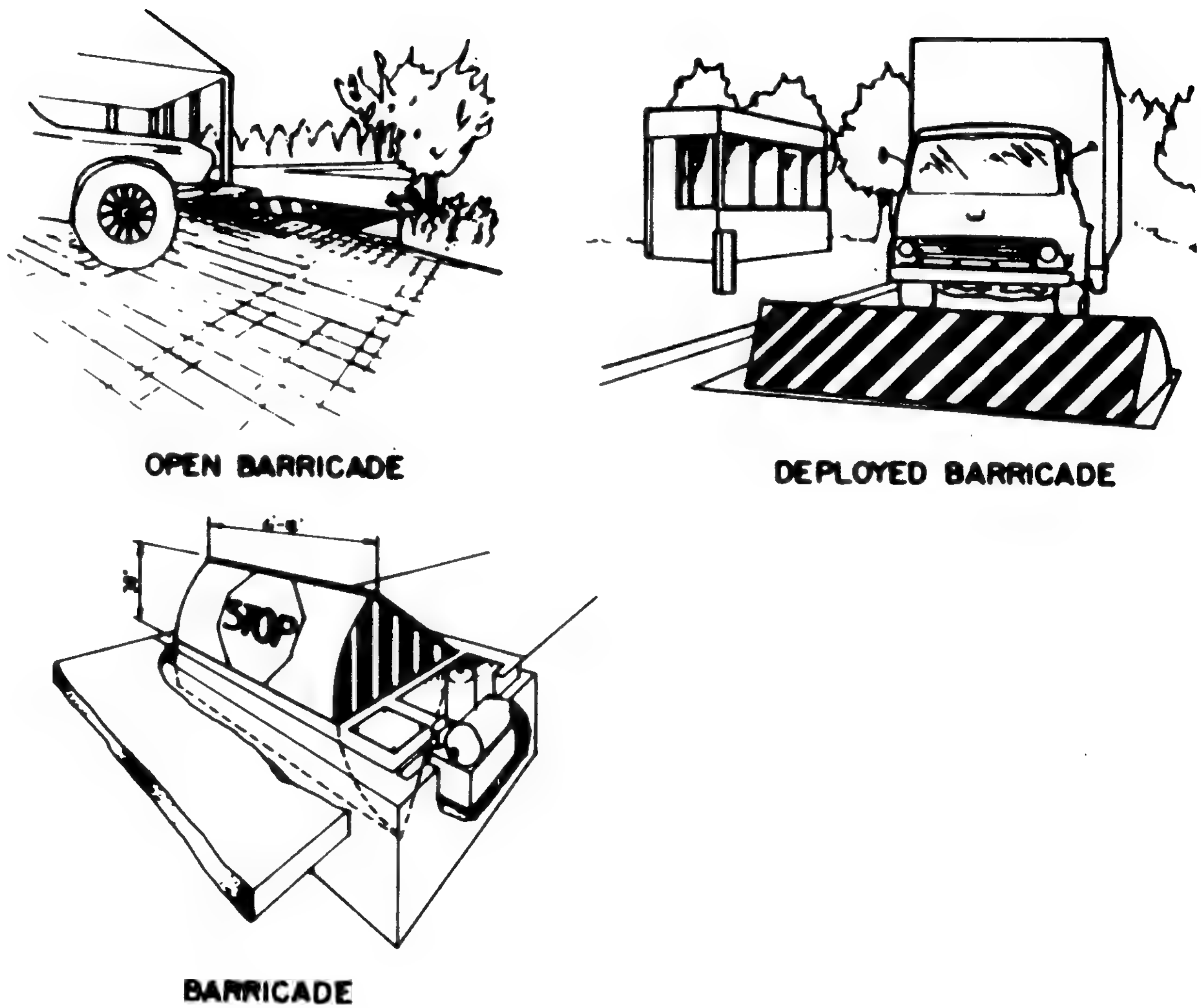


Figure 16. The rising step.

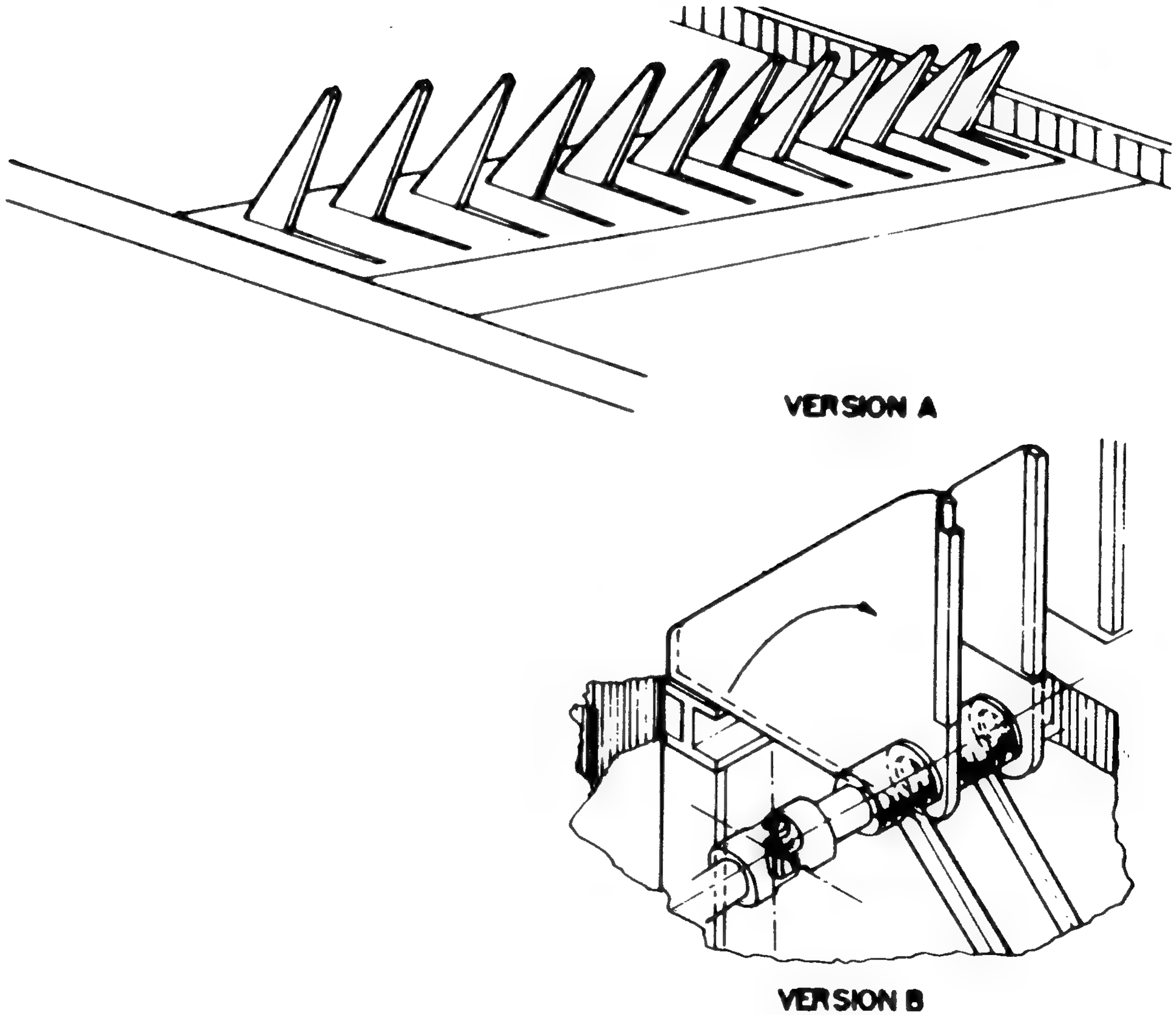


Figure 17. The rising blade.

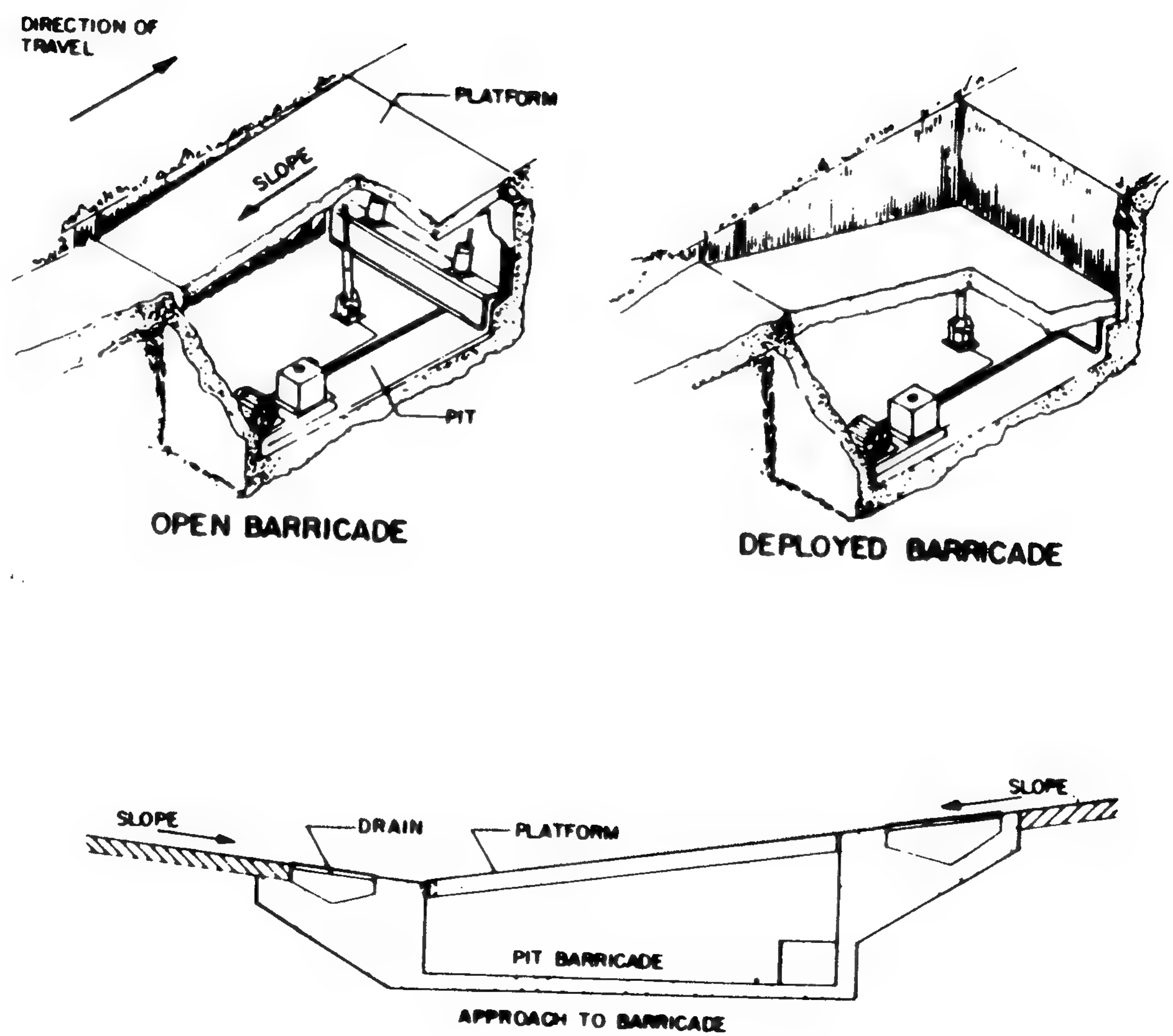


Figure 18. The "pit".

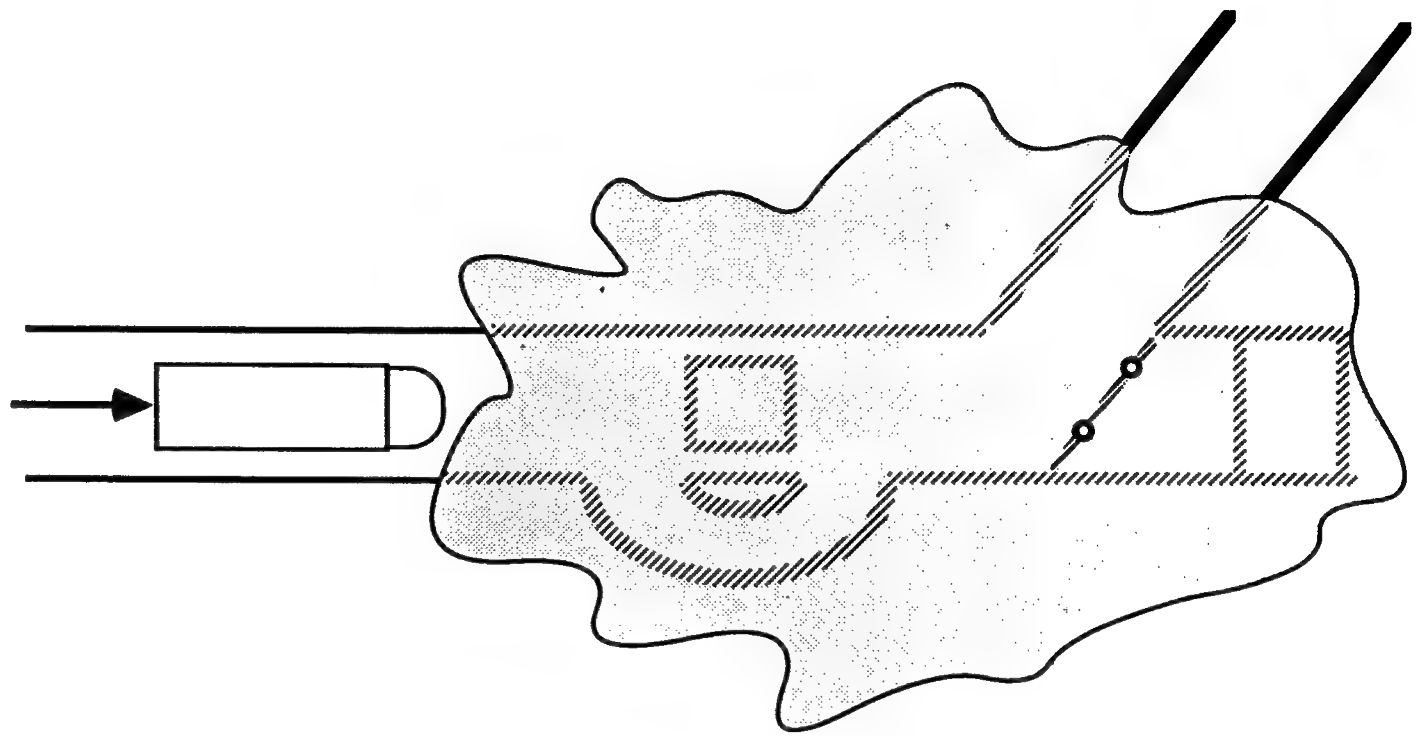

Figure 19. Rapidly dispersed visibility obscurant.

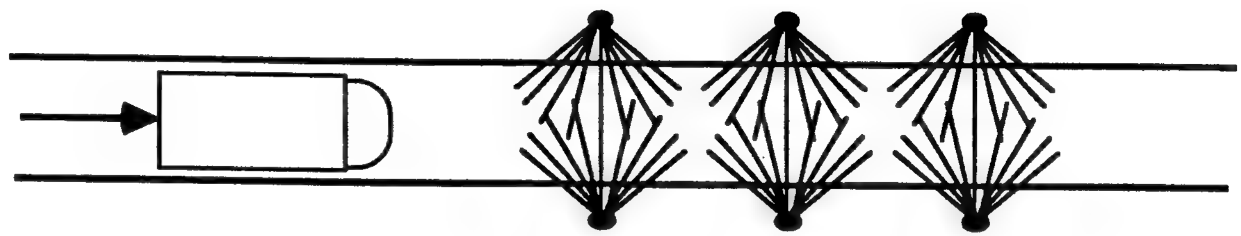

Figure 20. Antipersonnel chemical agent dispensers.

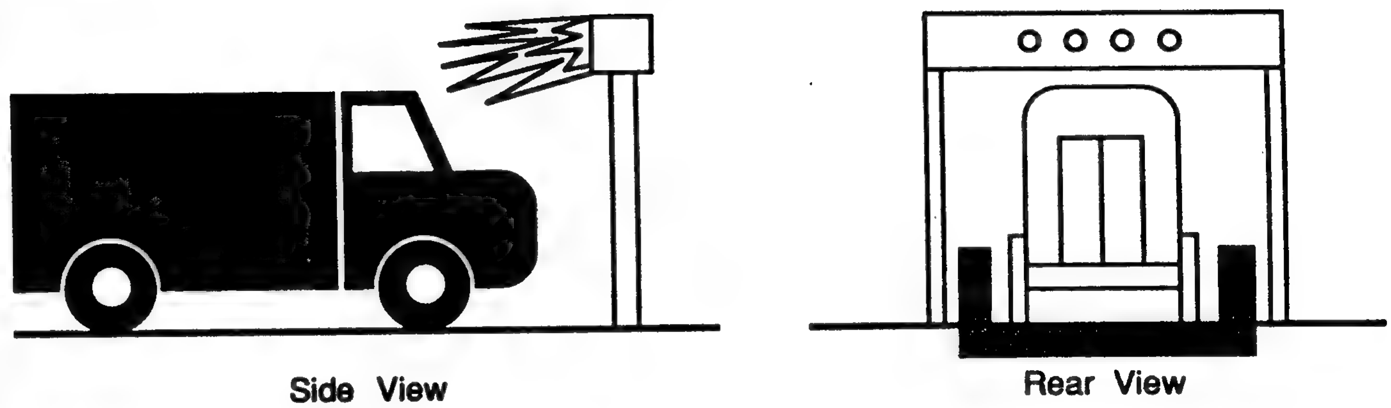


Figure 21. "Bridge" mounted antidriver countermeasures.

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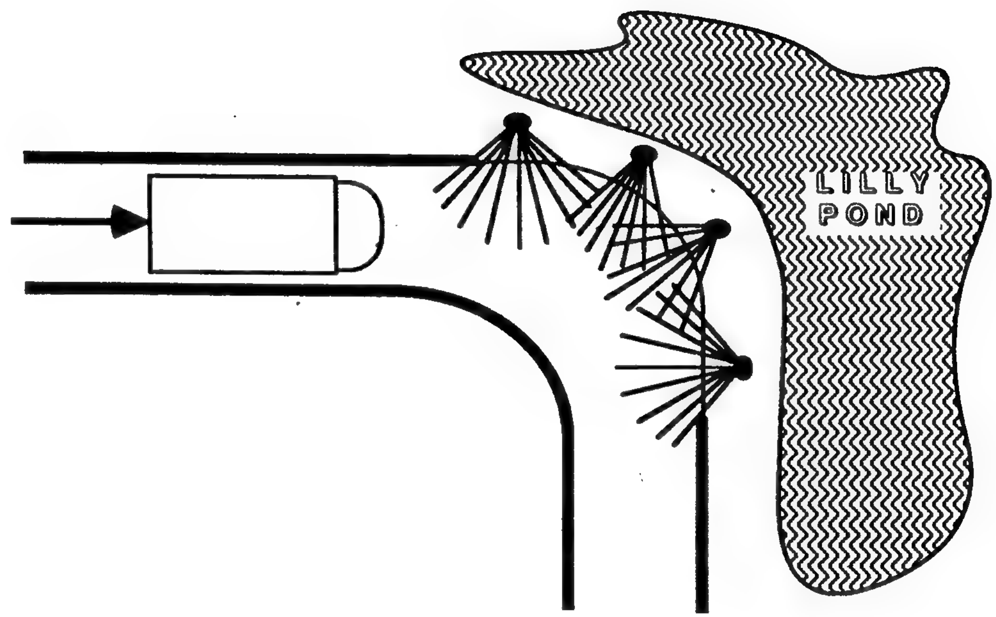


Figure 22. Reverse banked curve with dispersal of friction reducing agents.

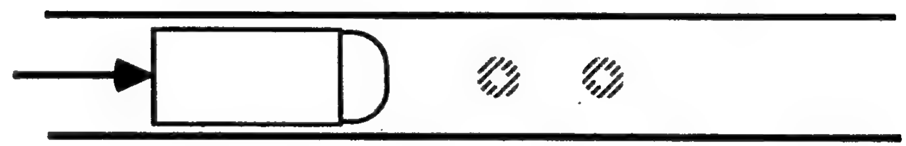

Figure 23. Command-controlled mines in roadway.

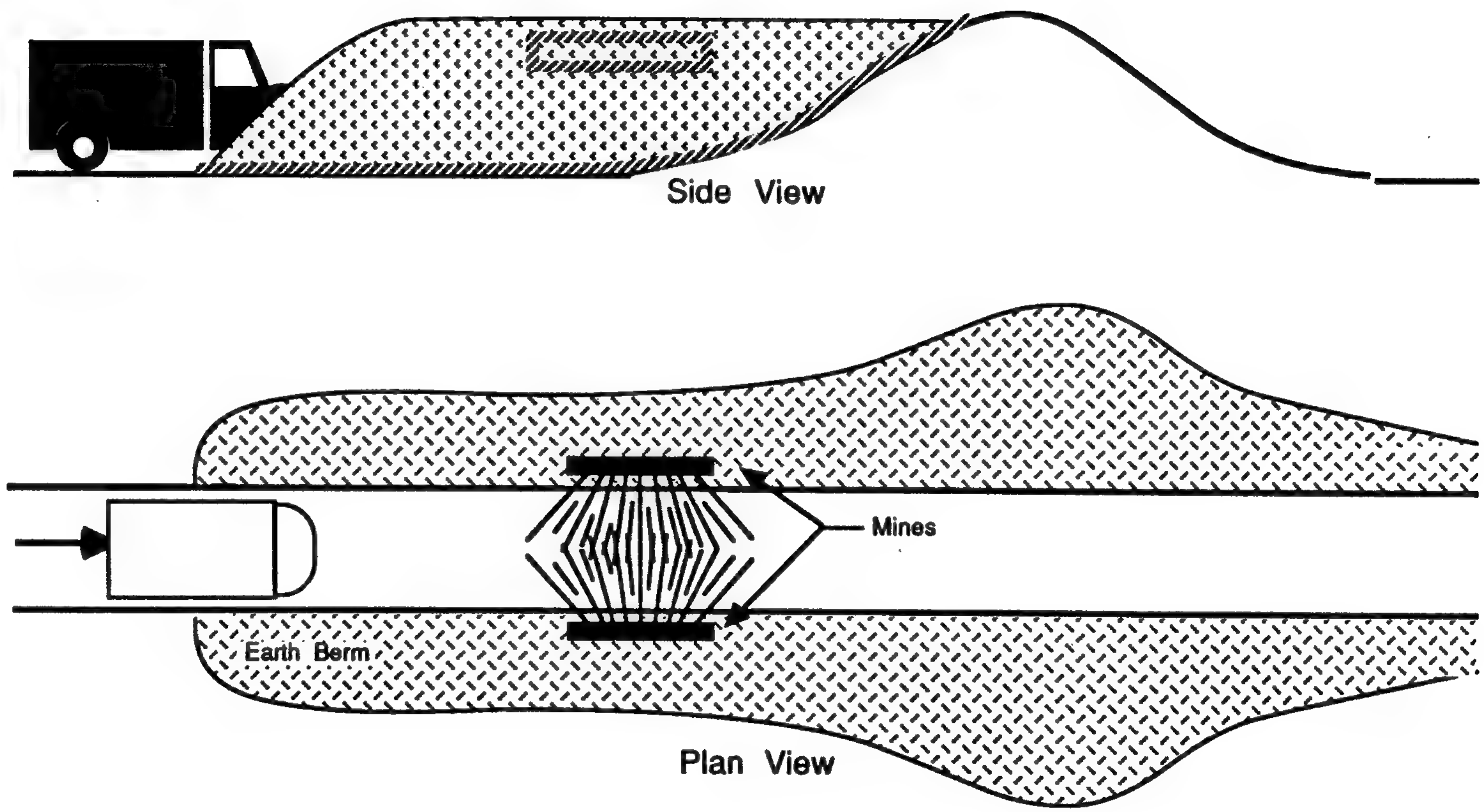


Figure 24. Command-controlled Claymore mines in roadside berms.

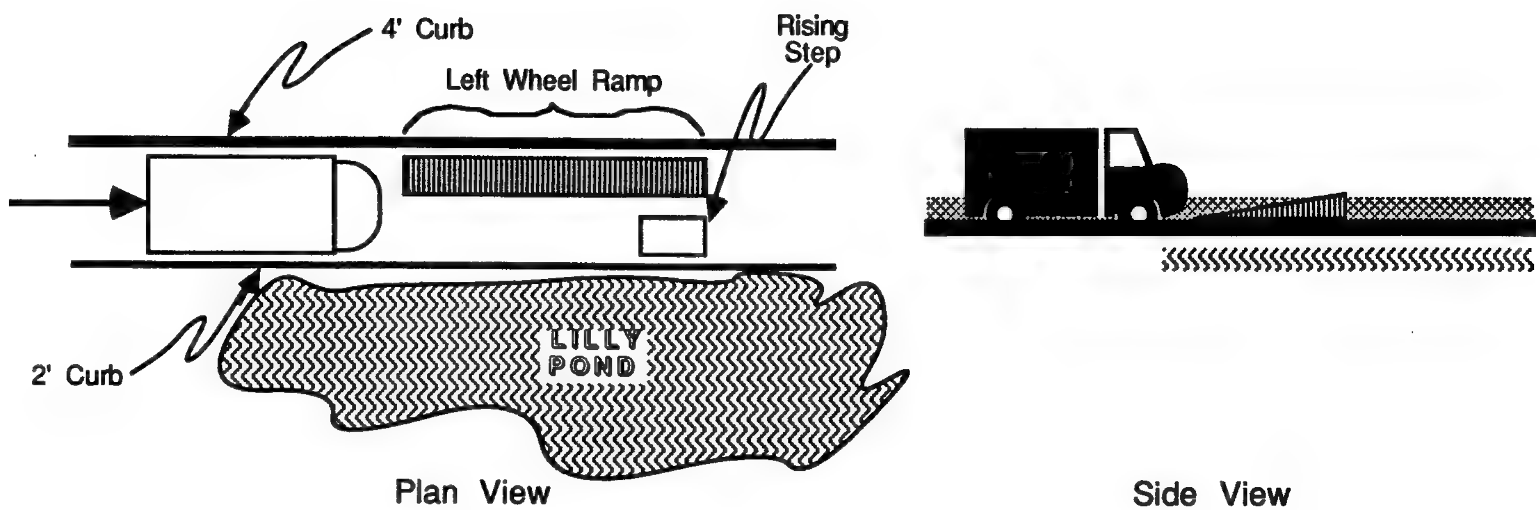


Figure 25. Command-controlled overturning ramp system.

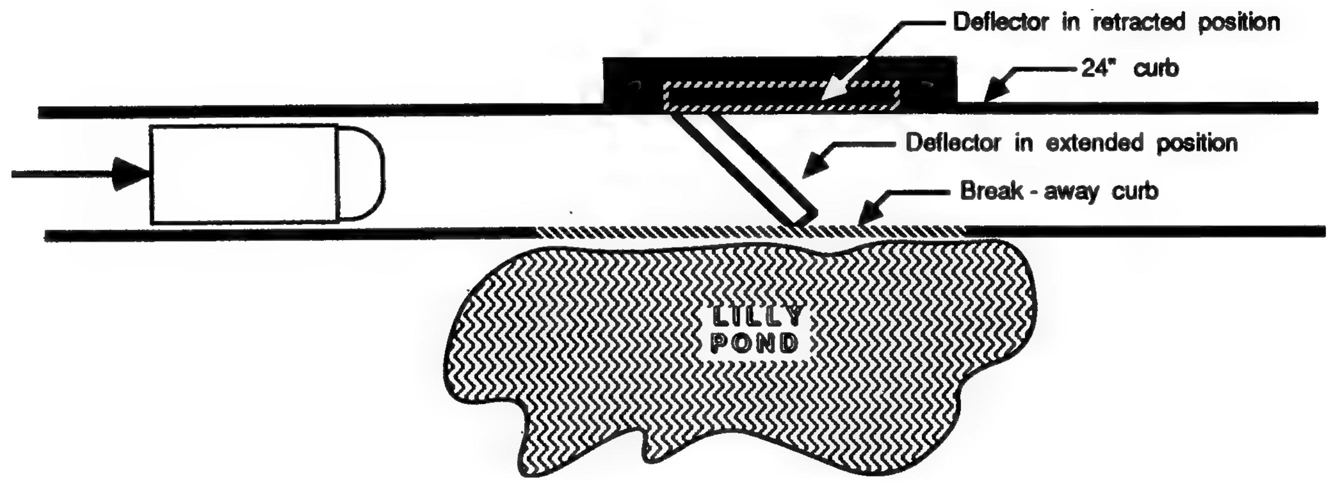


Figure 26. Command-controlled vehicle deflector system.

# SECURING U.S. ARMY

# SITE ACCESS POINTS

Prepared for the Conference

SECURING INSTALLATIONS
AGAINST CAR-BOMB ATTACK
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By

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Black & Veatch

Engineers-Architects

Kansas City, Missouri

May 17, 1986

B&V Project No. 00005.139

TABLE OF CONTENTS

LIST OF FIGURES

## LIST OF TABLES

# 1.0 INTRODUCTION

## 1.1 ACKNOWLEDGMENTS

The basis of this paper is a study conducted for the U.S. Army Engineer Division, Huntsville, Alabama and the Office of Chief Engineers, Washington, D.C. The study was conducted for the Huntsville Division by Black & Veatch during the winter 1984-85. Mr. Philip Brown, HNDED-PM was the project manager for the Huntsville Division, and Mr. Al Knoch, DAEN-ECE-T was the co-ordinator for the Office of Chief Engineers. Black & Veatch appreciates the opportunity to work with the Corps of Engineers on this topic and thanks them for their permission to submit this paper.

## 1.2 ABSTRACT

In 1985 Black & Veatch prepared a 12-sheet definitive drawing and accompanying design for the Office of the Chief of Engineers under contract to the U.S. Army Engineer Division, Huntsville.

The purpose of the definitive drawing was to provide local security planners with overall concepts and specific elements for defending Army installation access points from the forced entry of a vehicle loaded with explosives. The design criterion was formidible; the vehicle could be up to five tons in weight, travelling up to 55 mph, and loaded with up to 10,000 pounds of TNT. Other factors considered were installation site variations and the fact that blast effect, response time, and possible defense solutions are improved as the distance between the threat and the threatened increases. The study addressed all four possible combinations of short or long distances between public road and checkpoint and between checkpoint and installation.

Brainstorming sessions by a multi-disciplined team of engineers and architects produced several innovative design concepts. Cost, ease of construction, and practicality constraints were then applied to these concepts. The concepts' effects on traffic flow and safety were also evaluated. A design that would create an unacceptable traffic jam at the

checkpoint or which might cause harm to an innocent, confused, or mischievous, motorist would be unacceptable.

Descriptive and cost data were collected on manufactured and easily constructed gatehouses, static (immovable) barriers, vehicle (movable) barricades, and blast barriers. Explosive blast characteristics and highway design principals were also researched.

The final drawings allow a security planner to select elements within several security frameworks that will provide a solution appropriate to the unique installation conditions and the particular security threat level.

Additional study in the area of installation perimeter security and actual testing of the concepts developed by this Black & Veatch study are recommended. Both the static barriers and vehicle barricades are being tested by obvious agencies and manufacturers. This testing should continue and the results should be made available to base security personnel.

## 1.3 SUMMARY

This study identified a range of devices that may be combined in many ways to provide protection against the threats identified. The design cases identified for this study are very generalized; thus, they do not provide specific information on such factors as the threat, the terrain, the volume of traffic, and the distances between the public road, the checkpoint, and the main part of the base. This information is necessary to develop a realistic solution and to select the proper static barriers, vehicle barricades, gatehouses, and the number of incoming and outgoing lanes.

The development of these concepts became an exercise in finding different ways to combine various elements of a common vocabulary to provide concepts for each design case. Several of the concepts meet the conditions of more than one design case. The various concepts are frequently based on different assumptions and, thus, any one concept

will not be suitable for all situations. Both Concepts BB and BC solve the requirements of Case 4. However, Concept BB assumes that the access point can be placed between the base and the public road. Concept BC assumes that there is not adequate room to place the access point between the base and the perimeter of the base. Concept BC would work if the access point could be located in the heart of the base.

Therefore, this definitive design with a series of generalized concepts has been developed. These generalized concepts employ a common vocabulary of static barriers, vehicle barricades, gatehouses, and traffic control and detection systems.

Ideally, local security planners will be able to utilize one of these concepts by modifying it to conform to the local requirements of their installation. The vocabulary of static barriers, vehicle barricades, gatehouses, blast barriers, and traffic control devices should assist them in adapting these concepts for their use.

### 1.3.1 Summary of Findings

- A range of individual components, including gatehouses, static barriers, and vehicle barricades have been the subject of several previous studies. Some of these components meet the criteria given for this study. Some of these components have been or are being tested in the field.
- Gatehouses meeting the required criteria can be built from fairly common building materials. Also, such gatehouses are readily available as prefabricated buildings. The threat identified in this study will require the gatehouses to be designed with various degrees of protection.
- A wide range of static barriers have been identified by other studies. One reference classified these barriers as low, medium, and high band barriers according to their effectiveness. Some of these barriers have been tested, and some of them are suitable for use against the threat defined in this study.

- A limited variety of vehicle barricades are commercially available. There are manufacturers in Europe as well as the U.S. that design, test, and build these barricades. The barricades vary in their design parameters. The response times also vary from over 10 seconds to less than 2 seconds. Most of these barricades constitute a lethal force to occupants in a vehicle traveling above moderate speeds. A few of these barricades will stop the vehicle defined in this study and remain in condition to stop another vehicle. Many of the barricades will stop the design vehicle with some damage to the barricade. All of the barricades will stop the design vehicle if it were first slowed down by some other means.
- The various manufactured barricades may be controlled manually and by a wide variety of devices or systems including radar, detection loops, light beams, and treadle switches.
- TV cameras and card readers may be used with these devices to control the flow of traffic through the access points. Such devices will minimize the exposure of the guards to the threat.
- The vehicle barricades need to be at least 865 feet from major facilities on the military base to prevent severe damage to those facilities in the event of an explosion of 10,000 pounds of TNT at the barricades. The gatehouses should be 390 feet from the barricades to minimize the danger to the guards. Greater distances make it difficult for the guards to control the barricades and the ground between it and the gatehouses, while lesser distances place the guards in greater danger in the event of an explosion at the barricades. At 390 feet, the gatehouse should be designed for a blast overpressure of 3.5 psi.
- The approach distance to the vehicle barricades is determined by the operating time of the barricades and the reaction time of the guards or some controlling device.

- The vehicle approach to the vehicle barricades will control the approach speed of the design vehicle. Sharp turns and static barriers are effective in controlling the approach of all vehicles.

1.3.2 <u>Summary of Recommendations</u>

- A series of generalized concepts have been developed. These generalized concepts employ a vocabulary of static barriers, vehicle barricades, gatehouses, and traffic control and detection devices. Local security planners should be allowed to select a concept to meet their situation and then modify that concept using the vocabulary of design elements to make that concept meet their local requirements.

# 2.0 OBJECTIVES

## 2.1 CRITERIA

### 2.1.1 Purpose

The access points to U.S. Army installations shall assist the security force in deterring, denying, or at the least, delaying entry to a single terrorist or a group of terrorists intent on gaining entry by means of forcible vehicular entry.

### 2.1.2 Objectives

The access points shall meet several objectives to achieve this purpose. Barriers shall be provided at the access points that are capable of stopping a wheeled vehicle weighing up to five tons and traveling at a high rate of speed. The barriers shall work in the time frames allowed to resist the identified threat. The access points shall be designed to minimize the physical damage to the installation and the loss of life for military personnel, including the security force, resulting from an explosion of 10,000 pounds of TNT at the vehicle barricade. The gatehouses at the access point shall protect the guards from small arms fire and shall have firing positions to permit the guards to respond to armed terrorists. The access points shall permit some operational flexibility, i.e., permit the guards to establish various levels of security on a day to day basis, including complete vehicular searches. The access points shall accommodate a range of traffic conditions such as rush hour, visitors seeking information and/or admission, and trucks or buses to be checked. The access points shall not cause undue traffic congestion for legitimate personnel trying to enter or exit the base as part of their daily routines. Finally, the access points shall not present any undue threats to the life or safety of personnel with legitimate reasons for passing through these access points.

2.1.3 Other Goals

In addition to the above objectives, there are other goals that shall be considered in the design of access points. These include the following:

- It is desirable to maintain the image of our country as an open, democratic society that does not conceal its business behind forbidding barriers. However, it is recognized that there is some deterrent value in the visibility of some security measures. These two opposing goals must be reconciled in any concept.
- The concepts shall utilize components that are readily constructed or can be easily obtained from commercial sources. The components shall be simple in mechanical design and layout. They shall be foolproof in operation.
- The concepts shall be adaptable to a wide variety of sites. The individual components shall lend themselves to piecemeal installation. Local security planners will choose the components necessary to meet local terrain, customs, and/or budget limitations.
- The components shall be adaptable to a range of traffic conditions such as the number of entry and exit lanes for traffic.
- The first cost or construction cost, the operating costs, the maintenance costs, the replacement costs, and the manpower requirements shall all be considered.
- Reliability, including the degree of redundancy, shall be an important consideration.
- The costs in dollars, time, and personal injury for a false alarm shall be considered.

2.1.4 Operations

The following assumptions were made concerning the operation of the access points:

- Various levels of security must be maintained at these access points. These levels range from a guard staying in the gate-

house and waving on incoming traffic, to having one guard stay in the gatehouse while one or more guards stand in the lanes of traffic to check identification cards, or to having multiple guards remaining in the gatehouse while additional guards stop and search vehicles and personnel.

- The guards in individual gatehouses may be replaced by a card reader and/or TV cameras with the guards in a remote, protected location.

### 2.1.5 Additional Assumptions

The following assumptions were also made in the development of these concepts:

- The base property line is adjacent to the public road.
- The public road may be at right angles to or an extension of the base access road.
- The design vehicle may have obtained its speed at the property line of the base.

## 2.2 DEFINITION OF AN ACCESS POINT

### 2.2.1 General Concept

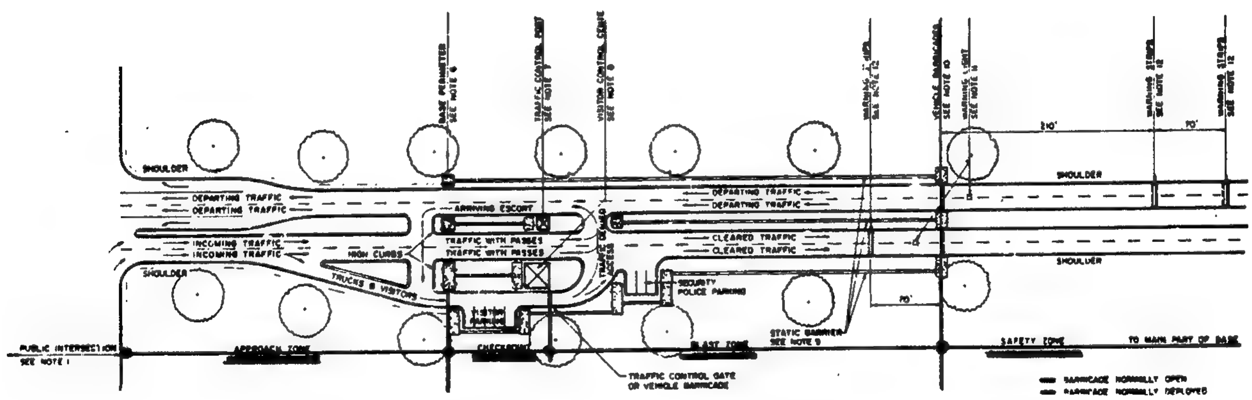



Figure 2-1 General Site Layout

The general concept shown in Figure 1-1 is subdivided into four zones. Each zone has its own function. Beginning at the public road, these zones include an approach zone, the actual checkpoint, a blast zone, and a safety zone. In addition, a vocabulary of elements has been developed to support these zones. This vocabulary includes traffic control devices, gatehouses, static barriers, vehicle barricades, and blast barriers. Many of these elements are illustrated herein.

2.2.1.1 Approach Zone. The approach zone lies between the public road and the checkpoint. It is the section of road that vehicles must traverse before coming to the actual checkpoint. This section of road is used for the following purposes:

a. To modify the speed of incoming vehicles so they are traveling at the proper speed when they reach the checkpoint.

b. To sort traffic by vehicle type so trucks and visitors have the opportunity to move into the proper lane before reaching the checkpoint.

c. To provide stacking space for vehicles waiting to pass through the checkpoint, especially during the morning rush hour.

d. To provide the guards at the checkpoint an early opportunity to identify threatening vehicles, including vehicles trying to enter the base through the lanes of departing traffic.

Various traffic control devices may be used to support these purposes. Speed and direction sensing devices may be used to detect vehicles traveling at excessive speeds and vehicles trying to enter the base through the lanes of departing traffic. Traffic friction devices may be used to reduce the speed of vehicles. Signs, lights, and other warning devices may be used to notify drivers of the upcoming checkpoint and to request them to follow specified procedures on speed and lane use. Static barriers may be used to limit the travel of incoming vehicles. These devices will be discussed later.

The length of the approach zone will vary due to the land available, the speed of incoming vehicles, the amount of vehicle weaving required

to sort out incoming traffic, and the means used to control the speed of incoming traffic. The length of this zone and the volume of traffic will determine the number of lanes required to provide adequate stacking room to minimize congestion in the public intersection.

2.2.1.2 Checkpoint. The checkpoint is the main controlling or security checking element of the access points. The checkpoint includes the gatehouses for the security force, the pavement to carry the various traffic patterns, and the devices necessary to support the work of the security force. The checkpoint must accommodate the following traffic patterns:

a. Incoming automobiles occupied by military personnel holding proper passes.
b. Visitors requesting information or access to the installation.
c. Military convoys including large tanks.
d. Delivery vans, trucks, and buses driven by civilian personnel that may require a complete search.
e. Vehicles given access to the installation.
f. Vehicles denied access.
g. All of the above vehicles as they depart the installation.
h. Vehicles coming from the installation to serve as escorts for visitors.

The checkpoint will require one or more buildings to shelter the security force. These buildings may include the following:

a. Traffic Check Post (TCP), used to house one or two guards at the left of single or double lanes of traffic.
b. Visitor Control Center (VCC), used to house additional guards who will oversee the entire checkpost, monitor security equipment, and check visitors and incoming trucks.
c. Elevated Control Tower, used to increase overall surveillance of the complete access point, especially in areas of rugged terrain.

The checkpoints must support at least three levels of operation including the following:

a. Open Base or Minimal Control. At this level, the checkpoint is used only to observe the flow of traffic. The incoming traffic would be waved on without any check of identification. Outgoing traffic would also pass freely through the checkpoint.

b. Limited Vehicle/Personnel Check. At this level, the Visitor Control Center is used to observe the flow of traffic and the operation of the guards. Individual guards would be posted in each lane of traffic to check the identification of each incoming vehicle and/or the persons within the vehicles. Outgoing traffic would either be checked in a similar manner or be allowed to pass freely.

c. Complete Vehicle Search. As with the previous level, the Visitor Control Center is used to observe the flow of traffic and the operation of the guards. Two or more guards would be posted in each Traffic Control Post, and guards would be placed in each lane of traffic to search incoming vehicles and/or the personnel within the vehicles. Traffic in the outgoing lanes of traffic may or may not be limited by vehicle barricades.

2.2.1.3 Blast Zone. The blast zone lies between the checkpoint and the vehicle barricades. This zone includes the vehicle barricades, the roadways between the checkpoint and vehicle barricades, and the static barriers along these roadways. The blast zone provides distance between the guards at the checkpoint and the vehicle barricades where a threatening vehicle may be finally stopped. This distance provides time to operate the vehicle barricades and some protection for the guards if that vehicle explodes at the barricades. The length of this zone is a compromise between three factors.

a. Vehicle barricade operating time.

b. Blast separation distance.

c. Effective guard control.

The vehicle barricades used to block the access points to vehicular traffic may be either normally deployed or normally open. If they are

normally deployed, a barricade must be opened for each vehicle admitted to the base. This operation will be slow, permitting four to fifteen vehicles to pass each barricade per minute. Where the blast zone and/or approach zones are very short, this operation may be necessary. However, where enough distance is available, leaving the barricades open will permit a greater volume of traffic to flow through the access point. If the barricades are normally open, the guards must have time to recognize a threatening situation and react, and the barricades must have time to be deployed before the threatening vehicle reaches it.

If the threatening vehicle explodes at the barricade, the explosion will generate a blast overpressure and flying debris and fragments. These effects will diminish over distance. Therefore, greater distances in the blast zone result in greater safety for the guards at the checkpoint. This distance is determined by the weight of the explosive charge on the vehicle. Various distances will be discussed later.

The guards at the checkpoint need to be able to have control over the ground at the vehicle barricades. They need to be able to see the barricades to verify their status and to see what people are doing to the barricades if they stop and get out of their vehicle. The guards also need to be able to shoot intruders stopped at the barricades. Greater distances for the blast zone make these actions more difficult.

Static barriers must be used along the road in the blast zone to keep all vehicles on the main road until they clear the vehicle barricades. The blast zone is in effect a sally port. If a vehicle is allowed into this zone by the guards, the static barriers and vehicle barricades are not required. However, if terrorists force their way through the checkpoint, the static barriers and vehicle barricades are used to entrap the terrorists. The static barriers are used to confine the terrorists to the roadways, and the vehicle barricades close off the end of the blast zone.

In a later section of this report it will be shown that for an explosion of 10,000 pounds of TNT, the blast zone should be 390 feet long to provide minimal protection for the guards. A vehicle traveling 60

miles per hour or 88 feet per second will cover this distance in 4-1/2 seconds. This time should be adequate for the guards to react and for the faster barricades to be deployed. This distance of 390 feet or 130 yards should not be excessive for the guards to control. If this distance cannot be achieved at a given site, the concepts shown in the drawings must be modified in two respects.

a. Blast barriers should be used between the checkpoint and the vehicle barricade.

b. The vehicle barricade should be deployed at all times.

Vehicle barricades must be used in the outgoing or departing traffic lanes as well as in the incoming lanes. Otherwise, terrorists could use these lanes to gain entry to the base.

2.2.1.4 Safety Zone. The safety zone completely surrounds the vehicle barricades, the assumed location where a terrorist vehicle will explode. This zone is the distance from the vehicle barricades and any inhabited buildings, public roads, or outdoor recreation areas. This distance extends in all directions to protect base personnel from an explosion at the vehicle barricade. The distance is determined by the weight of the explosive charge and the facility or personnel to be protected. For an explosion of 10,000 pounds of TNT, the blast zone should be 865 feet. If adequate distance is not available, it may be necessary to protect facilities against the effects of a blast.

### 2.2.2 Design Cases

Four different design cases may be identified by varying the distances available to provide the approach zone and the blast zone/ safety zone.

2.2.2.1 Case 1. This case occurs where there is a long distance between the public road and the checkpoint and another long distance between the checkpoint and the main part of the military installation, the headquarters building, personnel housing, or other threatened facility. This case may occur on a large, open installation in a rural area such as Ft. Leonard Wood, Missouri. This case implies that there

is adequate space to dissipate the force of an explosion at the gate without significant damage to the main part of the installation. It also implies that there is sufficient distance between the public road and the gatehouse to identify and control oncoming vehicles. Concepts A, B, C, D, E, and H may be used for Case 1. The other concepts, F and G, may also be used; however, their complexity is not necessary for Case 1.

2.2.2.2 Case 2. This case occurs where there is a long distance between the public road and the checkpoint and a short distance between the checkpoint and the main part of the military installation. This case may occur on a small, congested installation in a rural area, such as a small kaserne in rural Germany. This case implies that there is not adequate space to dissipate the force of an explosion at the gate without significant damage to the main part of the installation. It also implies that there is sufficient distance between the public road and the gatehouse to identify and control oncoming vehicles. Concepts A, B, C, D, E, and H may be used for Case 2, if adequate blast protection is provided. As with Case 1, Concepts F and G may also be used; however, their complexity is not necessary for Case 2. Blast protection may be provided using Concepts BA, BB, BC, BD, and BE.

3.1.4.3 Case 3 This case occurs when there is a short distance between the public road and the checkpoint and a long distance between the checkpoint and the main part of the military installation. This case may occur on a large, open installation in an urban area such as Ft. Belvoir, Virginia. This case implies that there is adequate space to dissipate the force of an explosion at the gate without significant damage to the main part of the installation. It also implies that there is minimal distance between the public road and the gatehouse to identify and control oncoming vehicles. Concepts F and G may be used for Case 3. The remaining concepts may also be used at a given location, if the "short distance" is sufficient to permit development of the approach zones at a given location.

3.1.4.4 Case 4 This case occurs where there is a short distance between the public road and the checkpoint and a short distance between the checkpoint and the main part of the military installation. This case may occur on a small, congested installation in an urban area such as Ft. McNair, Washington, D.C. This case implies that there is not adequate space to dissipate the force of an explosion at the gate without significant damage to the main part of the installation. It also implies that there is minimal distance between the public road and the gatehouse to identify and control oncoming vehicles. Concepts F, G, and BF may be used for Case 4 if adequate blast protection is provided. As with Case 3, the remaining concepts may also be used if the "short distance" is sufficiently long. Blast protection may be provided using any of the blast protection concepts.

# 3.0 VOCABULARY OF COMPONENTS

## 3.1 GATEHOUSES

### 3.1.1 Gatehouse Requirements

Four major requirements apply to the gatehouses. They must support the guard force activities. They must protect the guards from traffic and Level IV small arms fire. They must provide some protection against an explosion at the vehicle barricade. The guards must be able to return the fire of any attackers from a protected position.

### 3.1.2 Gatehouse Function

The gatehouses must function as control points and shelters for the guard force at the gate. As control points, the gatehouses become observation posts where the guards may oversee the whole access point. The gatehouses may also be used as control centers to control individual gates used at the access point. As shelters for the guards, the gatehouses may be located between the lanes of traffic to protect the guards from the traffic, the weather, and any identified threat.

Two types of gatehouses were developed; Traffic Control Posts and Visitor Control Centers. A third facility, an elevated guard tower, should also be considered for every access point.

Each access point shall have two or more of these facilities for the guard force. Except for very small installations, each access point should have a Visitor Control Center and one or more Traffic Control Posts. Multiple facilities are necessary for proper surveillance of the access point and for redundancy against terrorists.

Traffic Control Posts (TCP) are shown in the median strip between the incoming and outgoing lanes. Where there are more than one or two incoming lanes, additional TCPs may be placed to the left of each incoming lane to properly position the guard to interface with the driver of each vehicle. The TCP provides one or two guards with protection against the traffic, weather, and armed terrorists.

The Visitor Control Center (VCC) shown for most concepts is located to the right of the main incoming lanes of traffic. In this position it is easy to provide a lane of traffic around the right or far side of the facility where all visitors and trucks can be inspected. The VCC is the service center for the guard force. It houses a toilet, break area, and administrative space. It is also the control center for the access point with control over the vehicle barricades, traffic lights, access controls, and lighting.

An elevated tower may be required for the access points. From an elevated position, it would be easier to observe incoming traffic and to supervise operations at the access point. In areas of heavy forest or rough terrain, an elevated tower may be essential.

### 3.1.3 Protection from Small Arms Fire

Considerable study has been completed on the means to build bullet resistant structures. Four references were provided for this study. They include the following:

- "Wall Thickness Requirements for Protection Against M14 Service Ammunition" by R.S. Bernard; April 1975; U.S. Army Engineer Waterways Experiment Station.
- "Fundamentals of Protective Design for Conventional Weapons" by the Structures Laboratory; July 1984; U.S. Army Engineer Waterways Experiment Station.
- NAVFAC DM-13.1, "Physical Security"; March 1983; Department of the Navy, Naval Facilities Engineering Command.
- ANSI/UL 752-84, "Standard for Safety, Bullet-Resisting Equipment"; Underwriters' Laboratory, Inc.

The amount of material necessary to provide protection from small arms fire is determined by the weapon used, the round fired, the number of rounds fired, and the range or distance between the weapon and the material. Several of the references cited above define at least four levels of protection and the testing conditions for each level. The amount of material required to provide protection is also determined by the nature of the material. Even the thickness of concrete or steel is

determined by the compressive strength of the concrete or the yield strength of the steel. The following nominal thicknesses of materials may be used as preliminary guides for this study. They are based on a single round fired at point-blank range from an M14 rifle (Level IV Protection).

| Material | Ball Round | A.P. Round |
|---|---|---|
| Concrete 5,000 psi | 4 inches | 7 inches |
| Mild Steel 40,000 psi | 3/4 inch | 1-1/2 inches |
| Bullet Resistant Glass | 2 to 3 inches | |

There are several manufacturers that make either standard or custom designed gatehouses or guard booths. These gatehouses are complete structures, fully enclosed with bullet-resistant doors and windows, pass windows, lighting, etc. These gatehouses can be supplied by the following manufacturers:

Ballistic Shelters Corp.

Chicago Bullet Proof Equipment Co.

National Bullet Proof Inc.

The gatehouses shown in the concepts developed as part of this study could be built either on-site using suitable materials to build properly designed gatehouses, or some of the preengineered prefabricated shelters could be installed.

Greater threats than small arms fire may be identified. Such threats would include mortar fire, rocket fire, anti-tank weapons, etc. These greater threats will require additional protection or greater degrees of hardening. While it is possible to design protected facilities for these threats, it is not possible to provide large windows or viewing areas in protected structures. Without windows, a TCP or VCC will not be very effective. While television surveillance systems may be used with some effectiveness, the ability of guards to see everything going on around them is vital and cannot be completely provided by TV cameras.

### 3.1.4 Firing Positions

The gatehouses shall have provisions that will permit the guards to return the fire of any attackers from a protected position. For most gatehouses, firing ports may be provided without great difficulty. The manufactured gatehouses may be provided with firing ports. Gatehouses built on-site may be built with the same type of devices or with other openings suitable for the guards to use. However, as the degree of hardening is increased, it will become more difficult to provide this feature. Additional protected positions should also be provided to afford shelter and firing positions for the guards standing in the lanes of traffic. Sandbag enclosures are frequently provided for this purpose. Concrete walls or other types of shelters that might blend in with the access point and appear to be more friendly to the everyday visitor could also be provided.

### 3.1.5 Protection From an Explosion

The gatehouses may be protected from the effects of an explosion at the vehicle barricade in two ways. The distance between the two may be increased and the gatehouses may be protected to resist the effects of the explosion. These methods will be discussed later.

### 3.1.6 Other Operational Considerations

The need for toilets, lighting, emergency power, and communication systems should be considered by the local security planners. If significant pedestrian traffic is expected at the access point, consideration should be given to the desired route for the pedestrians, the means of separating the pedestrians from the vehicular traffic, and the type of control or gate required. At any access point, there will be visitors seeking information and/or admission to the military installation. These visitors must be processed without unduly hampering the flow of traffic. If they will be required to obtain a pass or wait for an escort, there must be some place for them to park their vehicles, some means of controlling their movement, and some means to keep them

for interfering with the operation of the guards. When their escort arrives, the escort must be able to turn his vehicle around and park it without obstructing traffic. Finally, if the visitors are denied admission, there must be a means available for them to turn around and leave by the outgoing lanes. It will be necessary for the local security planners to consider these factors and make the final determination on how they will be met.

3.1.7 Traffic Control Post (TCP)

Figure 3-1 shows a Traffic Control Post (TCP). The TCP is a 40 square foot facility for one or two guards. It provides shelter from traffic, weather, and terrorists. It provides the guards with an observation post and controls over the vehicle barricades and any toll gate or lights used to control traffic in that lane. The guard(s) in a TCP are only able to observe two to four lanes of traffic. Additional TCPs will be required if there are additional lanes of traffic, if the volume of traffic is heavy during periods of the day, or if the level of security requires close checking of incoming traffic. One TCP should be provided to the left of each incoming lane of traffic for the best protection. Each TCP shall be protected against traffic by concrete-filled guard posts and planters of reinforced concrete.

3.1.8 Visitor Control Center (VCC)

Figure 3-2 shows a Visitor Control Center (VCC). The VCC is a 645 square foot control center for the guard force at the access point. The building contains a guard station for guards to oversee the equipment and operation of the access point. The controls for the intrusion detection equipment, surveillance monitors, vehicle barricades, security lighting, and the communication equipment for the access point are located in this facility. Personnel in the visitor control center also handle the special cases of visitors and trucks applying for entry to the installation. The building has a waiting area for guards inspecting trucks and other vehicles. Visitors will come to this facility for information and to gain access to the

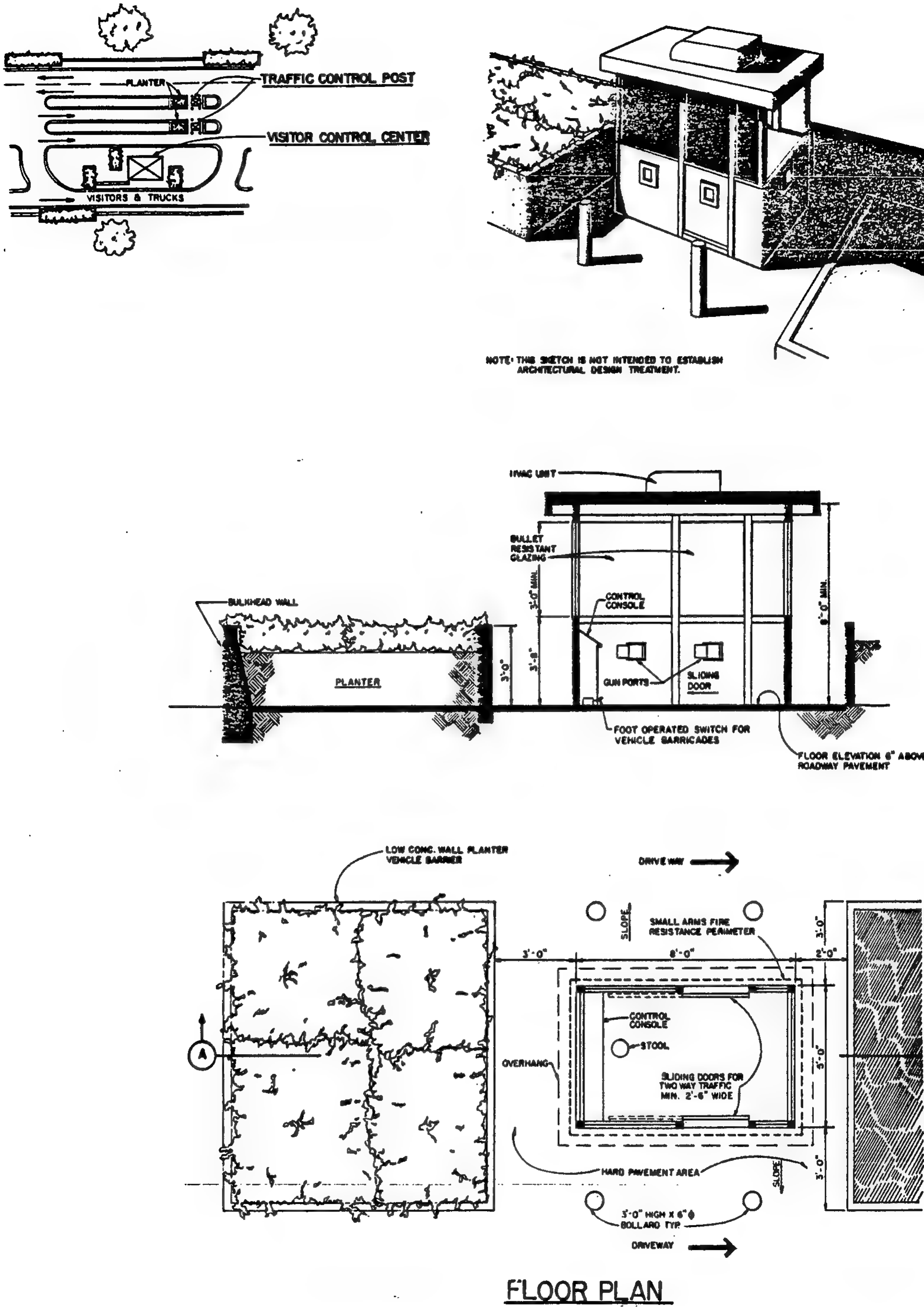
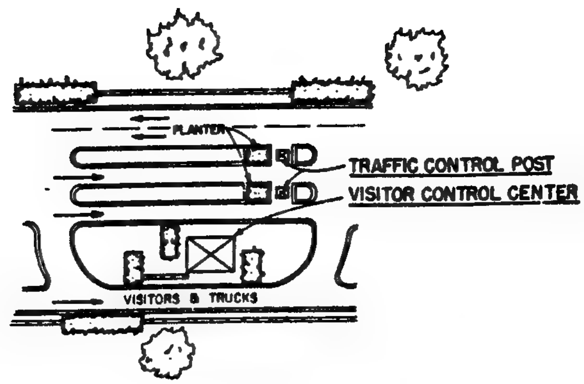
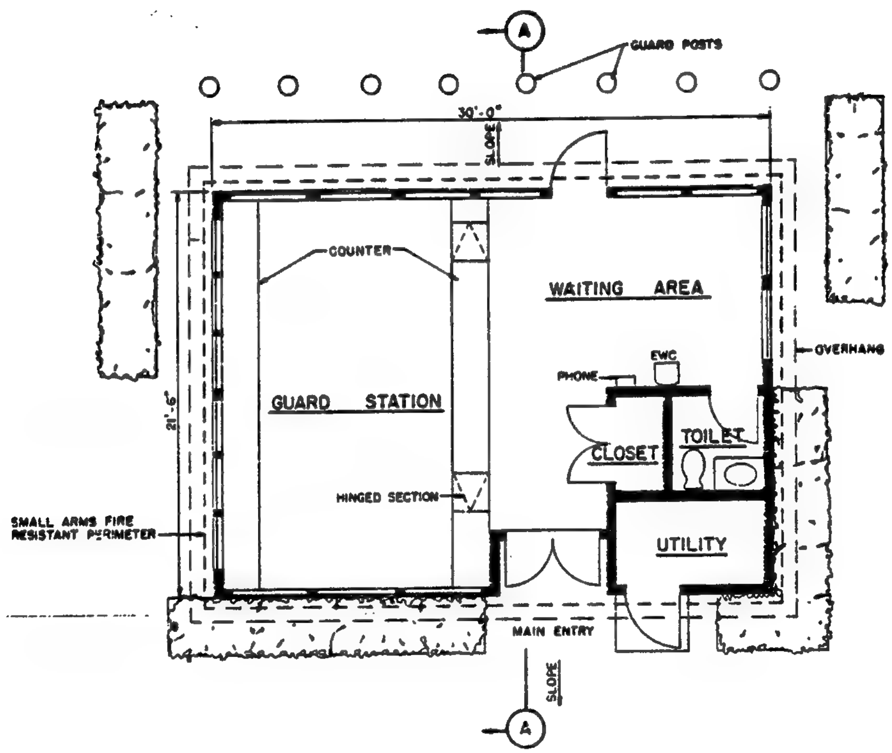



Figure 3-1 Traffic Control Post




GENERAL FACILITY PLAN




FLOOR PLAN

Figure 3-2 Visitor Control Center

installation. There are toilet facilities and vending machines for the guards. The access point should have two sources of electric power. If an emergency generator is required to provide a second source, it should be located in an expansion of the Visitor Control Center. Like the TCP, the VCC should be protected with static barriers like guard posts and concrete planters.

## 3.2 VEHICLE BARRIERS AND BARRICADES

### 3.2.1 Definition of Barriers and Barricades

Vehicle barriers are currently being studied by several government agencies. Two references were provided for this study that document some of this work. These references are as follows:

- o SAND 77-0777, "Barrier Technology Handbook"; April 1978; DOE, Sandia Laboratories.
- o Field Circular 19-112, "Use of Barriers in Countering Terrorism Situations"; August 1984; US Army Military Police School.

The latter reference categorizes barriers as static and active barriers. Static barriers are those that are placed and remain in place until they are no longer required. Active barriers are those devices used to control access through a gate or entrance. For these concepts, static barriers are used to channel the flow of traffic or to prevent vehicles from taking an unacceptable route at the access points. These barriers are called static barriers or barriers. Active barriers are used to deny passage to a vehicle and are called vehicle barricades or barricades. They are used to control access through a gate or access point.

### 3.2.2 Static Barriers

FC 19-112 also groups barriers into three subgroups identified as low band, medium band, and high band according to their degree of effectiveness. Static barriers may be natural features of the terrain

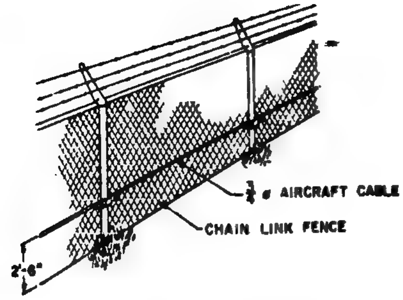
or manmade devices. If natural features are available they should be utilized. Manmade devices should blend with the surroundings if possible. The specific devices used for a given site shall be selected after considering the threat, local site conditions, and the relative costs of the static barriers. Figures 3-3 thru 3-5 illustrate some of the static barriers that should be considered for use. Low band static barriers are effective against personnel, but have very limited effectiveness against vehicles. They are useful for defining propertly lines and limits of travel. They include the following:

- o Barbed Wire Fencing: Multiple strands of barbed wire strung on fence posts.
- o Perimeter Security Fence: Chain link fencing.

Medium band static barriers are more effective against vehicles than the low band barriers. They are effective against slow moving, small, wheeled vehicles. Some, but not all, are effective against motorcycles. They include the following:

- o Enhanced Standard Fences: Chain link fencing enhanced with the addition of a steel cable strung near the base of the fence or with the addition of barbed tape concertina or GPBTO.
- o Metal Guardrails: Steel cables, steel shapes, or steel tubes stretched along low steel or wooden posts.
- o Guard Posts: Steel posts filled with concrete and set into the ground using concrete.
- o V-Fence: Two sections of chain link fencing erected to form a "V" with the bottom of the V filled with earth and a telephone pole and the upper part of the V filled with GPBTO.
- o Sectional Steel Fence: Sections of welded steel bars anchored to fence posts set in concrete. The effectiveness of this barrier will vary from low to high band.

High band static barriers are the most effective barriers used to stop moving vehicles. Even these barriers vary in their effectiveness, as all of them will stop small, wheeled vehicles, but not all will stop heavy, fast moving vehicles. They include the following:

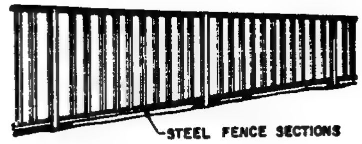



TYPE: MEDIUM BAND

CONSTRUCTION: STANDARD CHAIN LINK FENCE ENHANCED WITH A 3/4"ø OR LARGER AIRCRAFT CABLE IN FRONT OF THE FENCE POSTS

COST: $14.50/FT

COMMENT: NONE

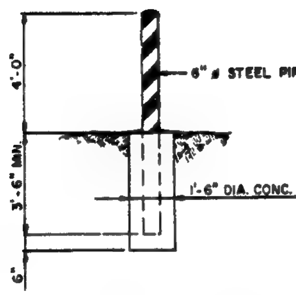



TYPE: LOW TO MEDIUM BAND

CONSTRUCTION: STEEL SECTIONS BOLTED TO STEEL POSTS SET IN CONCRETE FOOTING

COST: $44.00/FT

COMMENT: COST AND EFFECTIVENESS VARIES CONSIDERABLY WITH FENCE DESIGN.

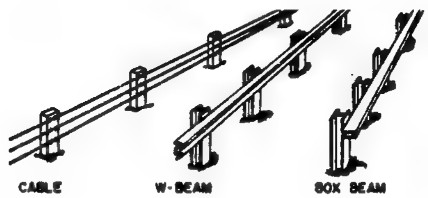



TYPE: MEDIUM BAND

CONSTRUCTION: 6"ø STEEL PIPE FILLED WITH CONCRETE SET IN CONCRETE FOOTING. LOCATED 3 FT ON CENTER

COST: $110.50/FT

COMMENT: MAY BE MADE REMOVABLE. A STRETCHED STEEL CABLE RUNNING THRU THESE POSTS MAY BE USED TO EXCLUDE MOTORCYCLES.

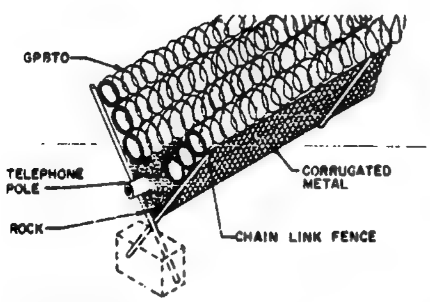



TYPE: MEDIUM BAND

CONSTRUCTION: 3-3/4"ø STEEL CABLES @ 3" OC ON POSTS SET ON 16 FT CENTERS, 27" HIGH; CORRUGATED W BEAM ON POSTS SET ON 12.5 FOOT CENTERS, 27" TO 30" HIGH; 6x6 OR 6x8 STEEL TUBE ON POSTS SET 4 FT TO 6 FT APART; 27" HIGH

COST: $13.00, $12.50 & 41.50/FT

COMMENT: NOT DESIGNED TO PREVENT HEAD-ON PENETRATION; WILL IMMOBILIZE A LIGHTWEIGHT VEHICLE ATTEMPTING INTRUSION

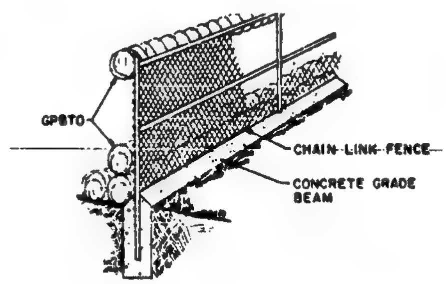



TYPE: MEDIUM BAND

CONSTRUCTION: DUAL CHAIN LINK FENCE SET AT 60° ANGLES TO FORM A "V", CORRUGATED SHEET METAL FORMS A "V" TROUGH 30" ABOVEGROUND & 12" BELOW GROUND, TROUGH FILLED WITH 2"-5" ROCK, TELEPHONE POLE & GPBTO

COST: $71.00/FT

COMMENT: EFFECTIVE AGAINST VEHICLES & PERSONNEL



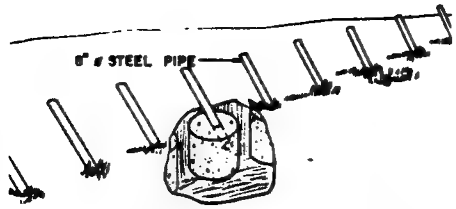

TYPE: MEDIUM BAND

CONSTRUCTION: STANDARD CHAIN LINK FENCING MAY BE ENHANCED WITH CABLE REINFORCING, CONCRETE GRADE BEAM BASE AND BARBED TAPE OBSTACLE

COST: $68.50/FT

COMMENT: NONE

Figure 3-3 Static Barriers



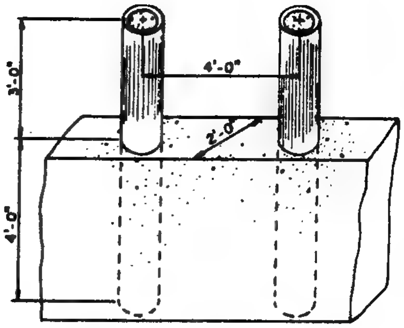

NOTE: PROTECTION AGAINST MOTORCYCLES MAY BE GAINED BY THREADING A HIGH STRENGTH STEEL CABLE THROUGH EACH STEEL PIPE.

TYPE: HIGH BAND

CONSTRUCTION: 6"Ø STEEL PIPE FILLED WITH CONCRETE OR RAILROAD RAILS, ANGLED AT 30° TO 45°, SET IN CONCRETE FOOTING, 3 TO 6 FT ON CENTER

COST: $142.50/FT ON 3'-0" CENTERS

COMMENT: EFFECTIVE AGAINST AUTOMOBILES AND TRUCKS; INEFFECTIVE AGAINST MOTORCYCLES UNLESS CABLE IS ADDED.

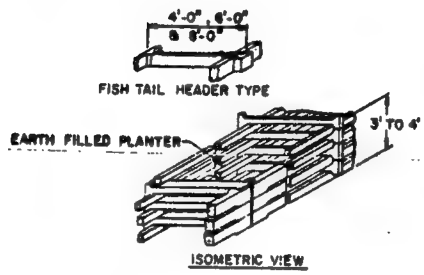



TYPE: HIGH BAND

CONSTRUCTION: MIN. 8"Ø, 1/2" THICK WALL, STEEL PIPE FILLED WITH CONCRETE, EMBEDED IN CONCRETE FOOTING 3 TIMES PIPE DIAMETER IN WIDTH BY 4 FT DEEP

COST: $236.50/FT

COMMENT: BOLLARDS MAY BE ANGLED. TO EXCLUDE MOTORCYCLES, RUN A STEEL CABLE BETWEEN BOLLARDS.

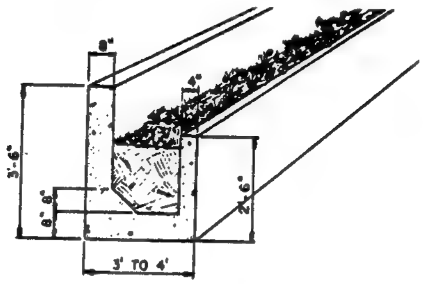



TYPE: HIGH BAND

CONSTRUCTION: PRECAST CONCRETE SECTIONS AS SHOWN OR CAST-IN-PLACE CONCRETE WALLS

COST: $203/FT

COMMENT: PRESENTS PLEASING APPEARANCE. SELECT PLANT MATERIAL WITH CARE TO AVOID OBSTRUCTING VIEWS OF ONCOMING VEHICLES.

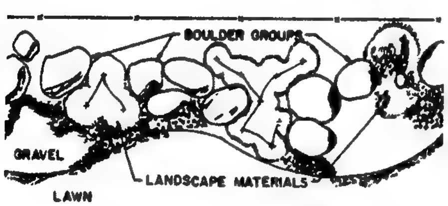



TYPE: HIGH BAND

CONSTRUCTION: PRECAST OR CAST-IN-PLACE HEAVILY REINFORCED CONCRETE PLANTERS, MIN. 6 FT LONG SECTIONS

COST: $60.50/FT

COMMENT: PRESENTS PLEASING APPEARANCE. SELECT PLANT MATERIAL WITH CARE TO AVOID OBSTRUCTING VIEWS OF ONCOMING VEHICLES.

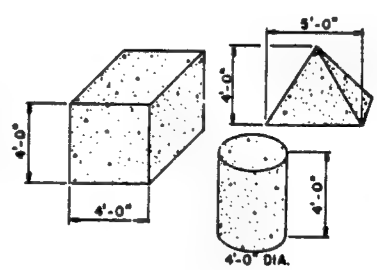



TYPE: HIGH BAND

CONSTRUCTION: FIVE TON GROUPINGS OF LARGE BOULDERS, MINIMUM OF 2 1/2 TONS, SOME PARTIALLY BURIED IN GROUND, GROUPS NOT MORE THAN 4 FT APART

COST: $15 TO $45/FT DEPENDING ON SOURCE OF BOULDERS

COMMENT: COST EFFECTIVE IF NATURAL MATERIAL IS READILY AVAILABLE



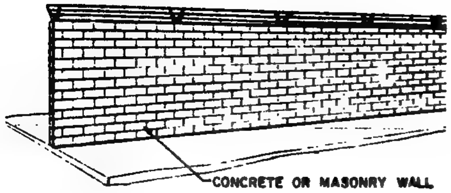

TYPE: HIGH BAND

CONSTRUCTION: PRECAST OR CAST-IN-PLACE CONCRETE SHAPES, ANCHOR TO GROUND

COST ON 8 FT CENTERS: $58.00/FT

COMMENT: USE A STEEL CABLE BETWEEN SHAPES TO EXCLUDE MOTORCYCLES.

Figure 3-4 Static Barriers

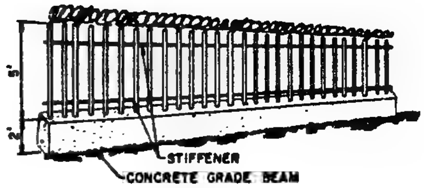



TYPE: HIGH BAND

CONSTRUCTION: CONCRETE OR MASONRY WALLS: RESULTS VARY WITH DESIGN

COST FOR 12" REINFORCED CONCRETE WALL 6 FT HIGH: $157.50/FT

COMMENT: ALSO PROVIDES VISUAL SCREENING

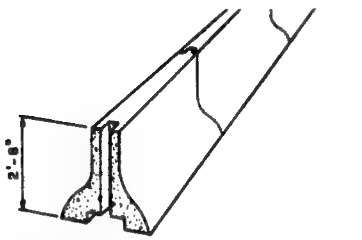



TYPE: HIGH BAND

CONSTRUCTION: CONCRETE FOOTING EXTENDING 2 FT ABOVE GRADE. IMPROVED STEEL FENCE

COST: $111.00/FT

COMMENT: NONE

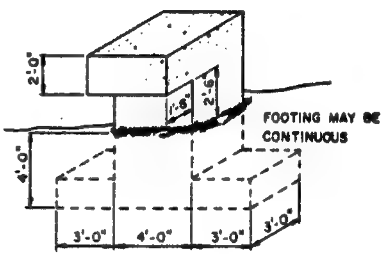



TYPE: HIGH BAND

CONSTRUCTION: PRECAST TONGUE & GROOVE SECTIONS OR CAST-IN-PLACE USING SPECIAL CONCRETE FORMING EQUIPMENT

COST: $32.00/FT

COMMENT: EFFECTIVE AGAINST A 3/4 TON TRUCK TRAVELING AT 50 MPH

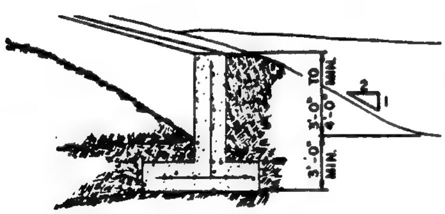



TYPE: HIGH BAND

CONSTRUCTION: PRECAST OR CAST-IN-PLACE CONCRETE SHAPES SET 6 TO 10 FT ON CENTER

COST ON 6 FT CENTERS: $304.00/FT

COMMENT: EXTENDED LIP WILL CATCH THE FRONT END OF THE VEHICLE AND CRUSH ITS GRILL, RADIATOR & HOOD. USE A STEEL CABLE BETWEEN TEETH TO EXCLUDE MOTORCYCLES.

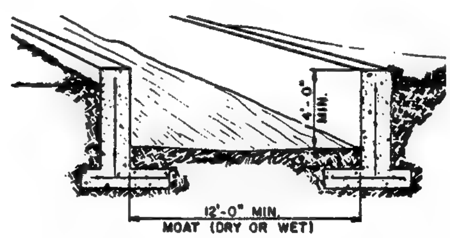



TYPE: HIGH BAND

CONSTRUCTION: CONCRETE RETAINING WALL BACKED UP WITH EARTH BERM, WALL FACES THREAT

COST: $128.00/FT

COMMENT: NONE




TYPE: HIGH BAND

CONSTRUCTION: CONCRETE RETAINING WALLS FORMING A MOAT

COST: $258.50/FT

COMMENT: MAY ALSO BE USED FOR ROAD DRAINAGE

Figure 3-5 Static Barriers

o Angled Posts: Concrete-filled steel posts set in the ground with concrete about four feet apart and angled outward.

o Bollards: Large concrete filled steel posts set about four feet apart in a continuous concrete footing. These may be strengthened by the addition of structural steel shapes used as railings.

o Concrete Shapes: Large precast concrete geometric shapes heavy enough to be difficult to move.

o Natural Boulders: Natural rock may be used if the individual pieces are large enough and heavy enough.

o Concrete Reinforced Fence: Steel bar fence with the base of the fence set in a concrete wall extending 24 inches above the ground.

o Dragon's Tooth Concrete Blocks.

o Earth-Filled Barriers: Multiple containers filled with earth or sand.

o Excavations or Ditches: Vertical cuts in the earth, ditches or moats, especially with vertical concrete walls.

o Earth Berms: Earth banks or berms with steep sides, especially with concrete walls and/or ditches.

o Masonry or Concrete Wall: Walls may be free-standing or backed with earth. Other materials such as steel shapes could be used to construct a monolithic wall or barrier.

o New Jersey Highway Barrier: Precast concrete barriers as used on the median strip for many Interstate highways. Note: These and other highway barriers are designed to be struck at a very oblique angle and may not be suitable to stop the threat identified by local security planners. The N.J. barrier may be breached by a 3/4-ton truck traveling at 50 mph. However, such a truck would be disabled and could not be used to carry an explosive charge on to the main part of the base.

In the concepts to follow, barriers such as guard posts (both vertical and angled), bollards, concrete shapes set in strategic locations, ditches or moats, concrete walls, earthfilled barriers, and the New Jersey Highway Barriers have been envisioned. However, specific static barriers were not identified. The selection of a specific barrier should be left up to the local security planners. They should make their selection on the basis of the threat identified, the terrain encountered, the visual appearance desired, and the cost of the various types of barriers. Other factors to consider would be maintenance costs, including the removal of plant growth and trash; repair or replacement costs when the barrier is breached; the ease of relocating the barrier; and the hazard presented to innocent personnel who may accidentally strike the barrier.

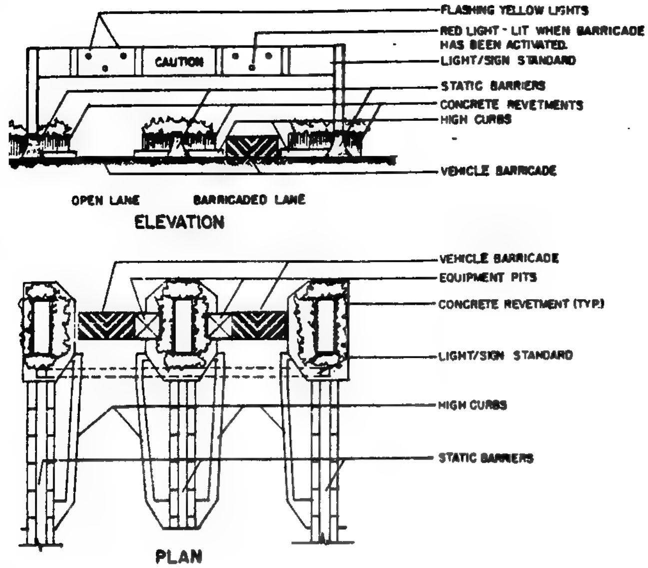
The installation of barriers around a site will not prevent penetration of the site by unauthorized personnel. Given time, any of these barriers may be penetrated. The barriers do prevent easy mobile access, from both outside and inside, do delay breaching, and do demonstrate an adversary's intent. Placing barriers near the outside perimeter forces the adversary to hand carry his weapons to his target.

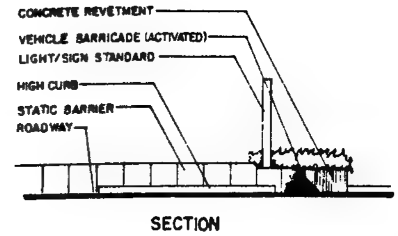
These static barriers are to be used at the main access points. Many will not exclude personnel on foot or on motorcycles. If these barriers are under the observation of guard personnel, protection against motorcycles and pedestrians may not be necessary. Otherwise those barriers should be supplemented to exclude these threats.

In addition to the problems of plant growth, windblown trash, and snow, detection sensor locations, and video assessment positions must be considered when adding static barriers to a site. Also, static barriers may be used by an adversary for firing positions or concealment.

### 3.2.3 Active Barriers or Vehicle Barricades

EC 19-112 also groups active barriers into three subgroups identified as low band, medium band, and high band according to their degree of effectiveness. Figure 3-6 shows one type of active barrier or vehicle barricade.

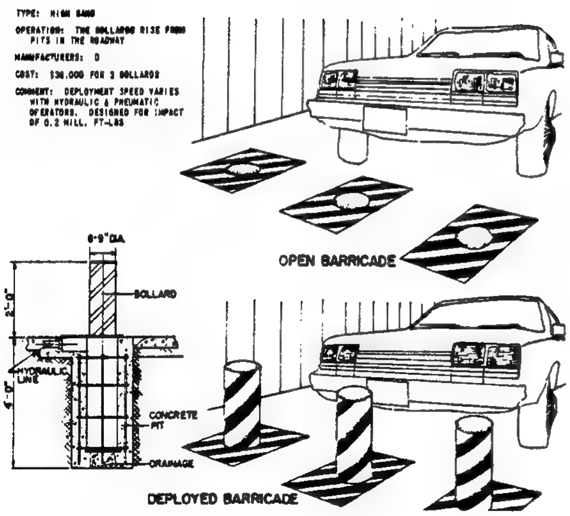


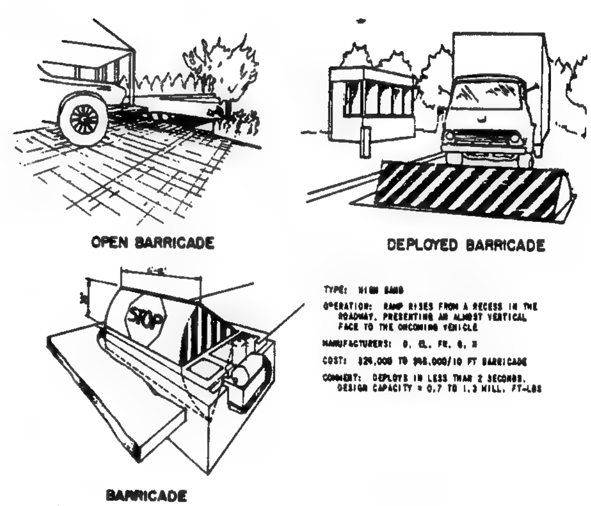




NOTES:

1. STATIC BARRIERS ARE REQUIRED TO PREVENT THE THREAT FROM GOING AROUND THE BARRICADES.
2. HIGH OR BARRIER CURBS AND CONCRETE REVETMENTS OR PLANTERS SHOULD BE USED TO NARROW THE ROADWAY AT THESE BARRICADES AND TO SLOW DOWN VEHICLES AS THEY APPROACH THE BARRICADES.
3. WARNING LIGHTS AND SIGNS SHOULD BE USED TO CAUTION DRIVERS ABOUT THE LOCATION OF THE BARRICADES. SIRENS, HORNS, AND GONGS MAY BE USED TO INDICATE DEPLOYMENT.
4. LOCATE OPERATING EQUIPMENT, HYDRAULIC PUMPS, AIR COMPRESSORS, ETC. IN A PROTECTED LOCATION NEAR THE BARRICADES.
5. DRAINAGE FOR THE PITS OF BARRICADES SHALL BE PROVIDED.
6. HEATING EQUIPMENT MAY BE REQUIRED IN SOME CLIMATES.
7. BARRICADE WIDTH MAY BE ADJUSTED TO MEET THE THREAT AND TO VARY THE COST OF THE BARRICADE.
8. THESE BARRICADES MAY REQUIRE HEATERS OR OTHER TYPES OF WEATHER PROTECTION FOR PROPER OPERATION IN SOME CLIMATES.

TYPE: HIGH DANG
OPERATION: THE BOLLARDS RISE FROM PITS IN THE ROADWAY
MANUFACTURERS: D
COST: $30,000 FOR 3 BOLLARDS
COMMENT: DEPLOYMENT SPEED VARIES WITH HYDRAULIC & PNEUMATIC OPERATORS. DESIGNED FOR IMPACT OF 0.2 MILL. FT-LBS




TYPE: HIGH DANG
OPERATION: RAMP RISES FROM A RECESS IN THE ROADWAY, PRESENTING AN ALMOST VERTICAL FACE TO THE ONCOMING VEHICLE
MANUFACTURERS: D, EL, FR, G, H
COST: $24,000 TO $92,000/10 FT BARRICADE
COMMENT: DEPLOYS IN LESS THAN 2 SECONDS. DESIGN CAPACITY = 0.7 TO 1.3 MILL. FT-LBS

Figure 3-6 Vehicle Barricades

Low band active barriers are effective against personnel, but have very limited effectiveness against vehicles. They include the following:

- Swing, Sliding, and Lift Gates: Gates normally found in chain link fences. May be enhanced with barbed wire, barbed tape, or GPBTO.
- Crash Beams: A steel pipe placed horizontally across the roadway and supported on similar vertical pipes.
- Cable Barriers: Systems of steel cables or chains that may be quickly raised to prevent passage.
- Tire Shredder: A steel plate with spikes set into the roadway that shreds the tires of an oncoming vehicle.

Medium band active barriers provide additional resistance against vehicles. They may restrain smaller or slow moving vehicles but probably not a heavy speeding vehicle. They include the following:

- Enhanced Gates: Standard swing, lift, or sliding gates reinforced with the addition of steel cables.
- Crash Beam: A heavy steel cross beam set in heavy standards on either side of the road. This is a reinforced version of the low band crash beam.
- Steel Gates: Specially designed heavy steel gates with the proper hardware necessary to block the passage of an on oncoming vehicle.
- Dispensed Agents: Liquid or gaseous agents dispensed on or in the roadway to impede the advance of an oncoming vehicle. The liquid agents that minimize the traction of an oncoming vehicle are of particular interest to this study.

High band active barriers, referred to as barricades in this study, are the most effective active barriers and are the barriers most likely to halt larger, fast moving vehicles. They include the following:

- Ramp Barricade: This device is a steel wedge assembly set in a pit cut across the roadway. It is activated by hydraulic fluid, air pressure, or electro-mechanical means and may be deployed in as little as one second.

- Operable Bollards: These are a series of bollards set in the roadway. They may be raised or lowered by hydraulic fluid, air pressure, or electric motors.
- Pits: These barricades consist of a concrete pit in the roadway with a steel lid or bridge that may be quickly dropped. The effectiveness of the pit is increased if the trailing edge is elevated above the leading edge.
- Pop-Up Barricade: This barricade consists of a pair of steel beams set in the pavement. The beams are quickly raised to impale a vehicle and trap it between the pavement and the beam.
- Blade: A series of heavy steel plates set on an axle forming a series of blades along the axle. The axle is rotated to raise the blades out of slots in the roadway to form a barricade.
- Plow Barricade: Like the blade barricade, a series of plows are mounted on an axle. When deployed, the plows are raised above the pavement to snare the undercarriage of a vehicle.
- Anti-Crash Gate: A heavy gate with a heavy reinforced base section that moves horizontally on rails.
- Net: An arresting net similar to those used on airfields to halt the forward motion of an aircraft at the end of a runway.

All of these barricades are commercially available. Some of them have been tested, and test data is available from the manufacturers. However, most of these barricades are not designed for and have not been tested against a five-ton vehicle traveling at a high rate of speed.

The concepts later shown envision active barricades; however, the selection of the barricade is left to the local security planners. Selection should be made on the basis of the threat defined, the terrain encountered, the speed of deployment, and the cost of the barricades. Other factors should also be considered such as the maintenance costs, the replacement or repair costs should the barricade ever be used, and the safety of innocent personnel caught by the barricade when it is

deployed. It should be noted that all of these barricades, with the possible exception of the arresting net, represent a lethal force to any oncoming vehicle. If one of these barricades is deployed to halt a terrorist trying to enter the base, any other traffic will encounter the same lethal barrier quite unexpectedly. The force of any vehicle ramming these devices at speeds above 20 MPH may be lethal to the occupants of that vehicle. Therefore, extreme caution must be exercised to ensure that these devices are not activated at the wrong time.

A moving vehicle has kinetic energy determined by the vehicle's weight and speed. On impact with a barricade, some of this energy is converted to heat, sound, and permanent deformation of the vehicle. The remainder of the kinetic energy must be absorbed by the barricade if the vehicle is to be stopped. The kinetic energy of a vehicle varies linearly with the vehicle's weight and by the square of its speed.

$$\text{Kinetic Energy} = \frac{W \times V^2}{2 \times 32.2}$$

W = Vehicle weight in pounds
V = Vehicle speed in feet per second

Thus, speed is more of a determinate of kinetic energy than weight. The standard illustration is the VW traveling at 60 MPH having more hitting power than an armored car weighing 30 times the VW but only traveling at 10 MPH.

If the vehicle's weight and speed exceed the design parameters of a barricade, one of two events will occur. The barricade may break loose from its restraints allowing the vehicle to continue with minimal damage. Or, if the barricade causes sufficient damage to the vehicle or the occupants before it fails, the vehicle will be unable to continue. The low band barricades like chain link gates will fail in the former manner. However, the high band barricades will fail in the second manner. If a barricade is damaged to the point where it must be replaced or its concrete housing repaired, the loss will be slight if it succeeds in stopping the threat.

Several options are available to the security planners wishing to provide a barricade capable of stopping a heavy speeding vehicle.

Multiple barricades may be used in tandem to stop the vehicle. Thus, if the vehicle were to break through the first barricade, the second barricade should stop the vehicle. However, the best option seems to be to prevent the vehicle from stiking the barricade at high rates of speed. This may be done by not allowing the vehicle to reach a high rate of speed or by diverting the vehicle if it has already attained that speed. If a vehicle's speed can be reduced by 50 percent, then its kinetic energy is reduced by 75 percent.

3.2.4 Approach to the Barricade

As indicated earlier, there are significant advantages to be gained in controlling the speed of the vehicle approaching the vehicle barricade. If the vehicle traveling at a high rate of speed is not allowed to reach the barricade, a more economical barricade may be used and the chances of stopping the vehicle are significantly increased. Law-abiding drivers will reduce their speed when approaching the gatehouses in response to warning strips (a series of very low speed bumps) or speed bumps in the road; speed limit, caution, or stop signs alongside the road; traffic or flashing lights over the road; or changes in the width of the road or road surface. However, these measures are not sufficient to slow down the determined terrorist.

There are more forceful ways to make the driver of any vehicle slow down. They include the use of horizontal and vertical curves in the road, stringent reductions in the road widths, and traffic congestion in the road ahead. To use these measures successfully, it is necessary to keep the driver on the road and prevent him from going around these hazards or taking a short cut across any open terrain. Three methods of reducing the speed of vehicles approaching the vehicle barricades are used in these concepts. They are the use of traffic friction devices, horizontal curves in the roads, and electronic controlling devices. Some of these devices are shown in Figure 3-7.

Over the years, highway designers have developed principles for road safety and high roadway volume. These principles include the use of wide traffic lanes, wide shoulders, median strips, multiple lanes of traffic, long sight lines, good curve alignments, minimum grades, ample vertical and lateral clearances, and smooth, dry, even pavements. They also include the lack of grade level intersections and visual distractions. By violating these principles, the ensuing friction will cause most drivers to slow down. These friction causing elements include the following:

- o Narrow lanes of traffic.
- o Single narrow lanes of traffic.
- o Narrow or no shoulders.
- o High curbs or barrier curbs.
- o Horizontal obstructions or static barriers along the edge of the traffic lanes.
- o Low vertical clearances that will also limit access by tall vehicles.
- o Speed bumps or cuts in the pavement.
- o Short sight lines.
- o Sharp curves.
- o Steep grades.

Single narrow lanes of traffic with barrier curbs or horizontal obstructions along the edge of the pavement are used with several of the concepts shown. Deleting the shoulder and adding barrier curbs along a single 12 foot wide lane has the effect of making drivers think that the lane is only 8 to 10 feet wide. Furthermore, if heavy concrete walls for planters or some other obstructions do reduce the pavement width to 8 to 10 feet wide at the TCP, it will be difficult for a terrorist to force his way past the TCP at a high rate of speed. The roadway opening at the TCP can be restricted further by using an overhead obstruction such as sign standards, an overhead canopy, or a massive portal structure with only enough clearance for automobiles.

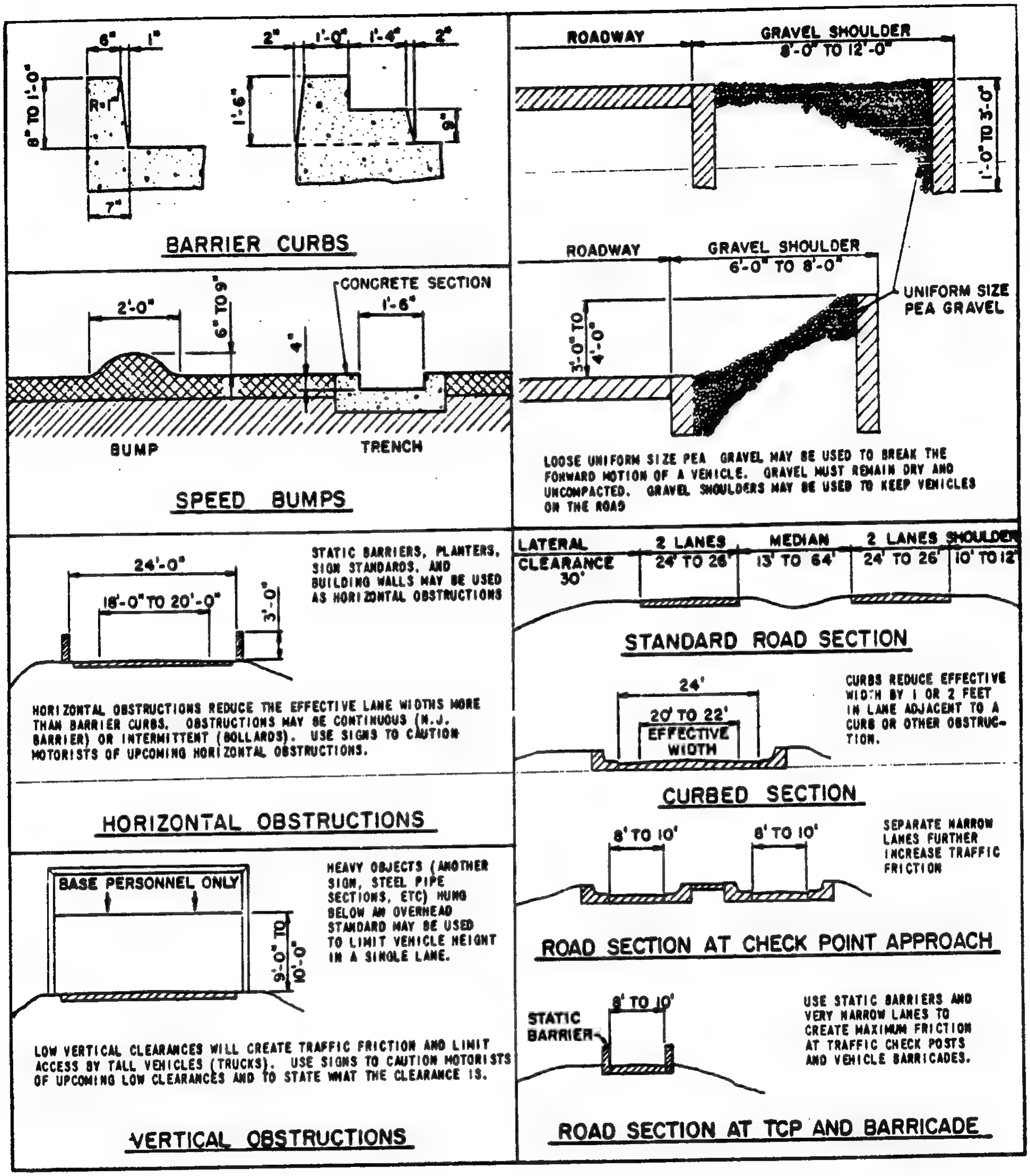



Figure 3-7 Traffic Friction Devices

These vertical and horizontal obstructions make it necessary to have a separate entry for trucks. However, if trucks are separated from cars, these heavier vehicles capable of hauling large amounts of explosives may be restrained while they are more thoroughly checked without tying up automobile traffic. Automobiles, which constitute most of the traffic at an access point, are capable of carrying terrorists with explosives. Low, narrow portals cannot be expected to exclude them. However, such a portal will make it more difficult for the terrorists to force their way past a checkpoint at high speed. Thus, the guards will have a greater opportunity to spot such a vehicle and to react to its presence.

Using these principles, narrow lanes have been used in the concepts for this study at both the TCP and the vehicle barricades. The vehicle barricades are expensive devices and any increased width increases their cost and, to some extent, reduces their effectiveness. Therefore, their width should be minimized with the use of static barriers and traffic friction devices. The static barriers are also required to keep a terrorist from simply driving around a barricade.

Sharp curves are another traffic friction device that should be used wherever possible. A sharp curve gives a driver a very limited choice. Either he slows down or he will lose control of his vehicle in the curve. The consequence for losing control should be crashing into an obstruction or static barrier or leaving the road to end up in a ditch or other type of static barrier. Such curves may be used before the TCP, making it difficult to speed past the guards, and before the vehicle barricades, making it possible to minimize the impact on the barricades.

The American Association of State Highway and Transportation Officials publishes standards for rural highways. One table found in the Standard Handbook for Civil Engineers includes their recommended curves for exit ramps on highways.

Table 3-1

SAFE CURVE SPPEDS

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Ramp Speed, MPH | | | | | | | | |
| Desirable | 25 | 35 | 45 | 50 | 55 | 60 | 60 | 65 |
| Minimum | 15 | 20 | 25 | 30 | 30 | 30 | 35 | 40 |
| Corresponding, Minimum Curve Radius, Ft. | | | | | | | | |
| Desirable | 150 | 300 | 550 | 690 | 840 | 1,040 | 1,040 | 1,260 |
| Minimum | 50 | 90 | 150 | 230 | 230 | 230 | 300 | 430 |

These must be considered safe curves for the respective speeds. These speeds may be exceeded without losing control of a vehicle.

A car will skid out of control in a curve when the centrifugal force of the vehicle exceeds the frictional force between the vehicle and the pavement.

Centrifugal Force (CF)

$$CF = \frac{W \times V^2}{g \times R}$$

Where:
V = Velocity, FPS
R = Radius of Curve, Ft.
g = Acceleration of Gravity
= 32.2 ft/sec$^2$

Frictional Force (FF)

$$FF = W \times u$$

W = Vehicle Weight, Lbs.
u = coefficient of friction

Critical Curve Radius

The critical curve radius occurs when CF = FF

Thus, $$\frac{W \times V^2}{g \times R} = W \times u$$

Or, $$R = \frac{V^2}{g \times u}$$

When, $g = 32.2$ ft/sec$^2$

$$V_{ft/sec} = \frac{V_{MPH} \times 5280 \text{ ft/M:}}{3600 \text{ sec/hr.}}$$

u assumed to be .6

$$\text{Then } R = \frac{(5280 \times V)^2}{3600^2 \times 32.2 \times 0.60}$$

$$\text{or} \quad R = \frac{V^2}{8.98}$$

R = Radius of Curve, ft.
V = Velocity of Vehicle, MPH

This equation gives the following critical curve radii.

Table 3-2

CRITICAL CURVE RADII

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Velocity, MPH | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 65 |
| Radius, Ft. | 25 | 44 | 70 | 100 | 136 | 178 | 225 | 278 | 336 | 400 |

The curves used for access points should be based on radii selected between the two extremes shown in the table below.

Table 3-3

DESIGN CURVES

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Vehicle Speed, MPH | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 |
| Safe Curve Radii, Ft. | 50 | 90 | 150 | 230 | 300 | 430 | 550 | 690 | 840 | 1,040 |
| Critical Curve Radii, Ft. | 25 | 44 | 70 | 100 | 136 | 178 | 225 | 278 | 336 | 400 |

Using Table 3-3 it is possible to determine that a safe curve radius for 30 MPH is 230 feet. Using the same table, it appears that a vehicle can go through a curve with a radius of 230 feet at 45 MPH before it skids out of control. Therefore, a curve with a radius of 230 feet may be used in front of a vehicle barricade. That curve should be posted with a safe speed of 30 MPH. However, a terrorist will be able to strike the barricade traveling 40 to 50 MPH before losing control of his vehicle.

### 3.2.5 Control of Barricades

The high band barricades act quickly and can be controlled by a wide range of devices. Any device capable of acting like a switch will activate these barricades. The following are some of the devices that may be used:

- Push button switches in the gatehouses.
- Foot-operated pedal switches in the gatehouses.
- Hand operated switches carried by the guards, both hard wired and wireless.
- Radar used to detect excessive speed.
- Radar used to detect vehicles moving in the wrong direction.
- Detection loops in the pavement used to detect excessive speed.
- Detection loops used to detect vehicles moving in the wrong direction.
- Detection loops used to detect unauthorized entry past a gate or other control device.
- Light beams used like detector loops.
- Treadle switches in the pavement used like detection loops.
- Access control equipment like card readers, key operated switches, and cypher locks used to open normally deployed barricades.
- Access control computer systems used to detect an illegal entry.
- Radio controlled devices in the gatehouses or carried by the guards.

Thus, there are a wide range of devices that may be used to activate the vehicle barricades. Many of these may be used as automatic controllers without any action by the guards. These automatic devices may be used to minimize reaction time by eliminating the guard's reaction time. They will also work even if the guards are distracted or unable to respond. Unfortunately all of the automatic devices are prone to giving false alarms. Since the force of any vehicle ramming these

barricades at speeds above 20 mph may be lethal to the occupants of that vehicle, extreme caution must be exercised to ensure that the barricades are not activated at the wrong time. The use of automatic controls should be avoided because false alarms could have deadly consequences.

It is recommended that the guards in the gatehouses should have manual control over the barricades. The guards are in the best position to recognize the need to deploy the barricades. They should be able to distinguish confused, inattentive, or drunk drivers from terrorists intent on forcing an entry. The automatic systems could be used to sound an early warning for the guards in the TCP or VCC. If the threat is great enough, the guards may be given the option of switching over to automatic systems. However, for normal, everyday use, the guards should have manual control. The consequences of a false alarm and the likelyhood of having frequent false alarms are too great if the barricades are automatically controlled. The concepts included with this study show more than one gatehouse. Each guard facility at the checkpoint should have control over all of the barricades. This redundant control will make it difficult for terrorists to force an entry by eliminating a single gatehouse or TCP.

The barricades may be deployed in one to ten seconds. The more effective barricades have emergency deployment times of less than two seconds. With proper training, a guards' reaction time should be about the same. The guards should be able to recognize the high speed approach of a terrorist before the terrorist reaches the checkpoint. The terrorist making a normal approach will presumably be recognized at the checkpoint. However that terrorist will not be moving at a high rate of speed. Assuming the worst case, the vehicle barricades must be in deployed position within four seconds after the speeding terrorists passes the checkpoint. Table 3-4 gives the distance a terrorist can cover in four seconds at various speeds.

Table 3-4

TIME VERSUS DISTANCE

| Average Vehicle Speed, MPH | Per Second | Distance Covered, Ft. in 4 seconds |
|---|---|---|
| 30 | 44 | 176 |
| 40 | 59 | 235 |
| 50 | 73 | 294 |
| 60 | 88 | 352 |
| 70 | 103 | 411 |

These distances may be used to determine the distance between the checkpoint and the vehicle barricades. This distance is identified as the blast zone on the drawings illustrating the various concepts.

## 3.3 TRAFFIC CONTROL DEVICES

Various devices may be used to control the flow of traffic. Some of these are shown in Figure 3-8. These devices may be used for the following purposes:

- To control vehicle movement.
- To control vehicle speed.
- To detect excessive speed.
- To control vehicle direction or routes.
- To detect movement in the wrong direction.
- To advise drivers of upcoming hazards, speed changes, and stops.
- To advise drivers about which lanes of traffic to use.
- To indicate the presence of a vehicle.
- To control vehicle access.
- To determine stopping points.
- To control toll gates and other traffic control devices.
- To identify vehicles violating the checkpoint.

The following devices may be used for these purposes:

- Static barriers, especially planters.
- Warning strips or rough sections of pavement.

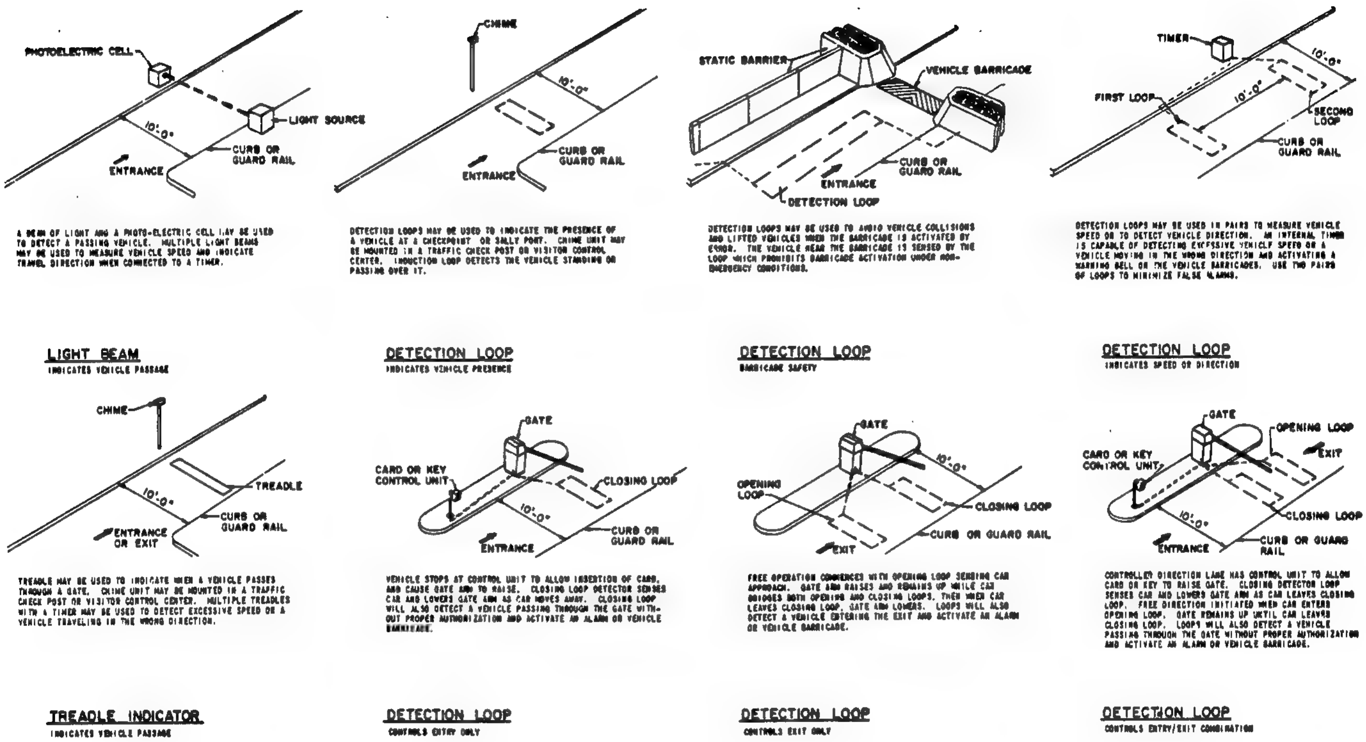



Figure 3-8 Traffic Control Devices

- Speed bumps.
- Traffic signs.
- Pavement markings.
- Traffic lights.
- Alarms and gongs.
- Toll gates.
- Electric detection loops.
- Photelectric cells and light beams.
- Treadle switches.
- Cable TV.
- Radar.
- Parking access control equipment including cypher locks, key operated locks, card readers and access control computers.

3.3.1 Traffic Control in the Approach Zone

Signs, pavement markings, static barriers, warning strips, speed bumps, and traffic lights may be used in the approach zone to warn drivers of the upcoming checkpoint, to modify their approach speeds, and to advise them about which lane they should be entering. Radar and electric detection loops may be used to monitor vehicle speed and direction.

3.3.2 Traffic Control in the Checkpoint

Signs, traffic lights, alarms, static barriers, pavement markings, toll gates, vehicle detectors, and the guards may be used to control the movement of traffic through the checkpoint. Electric detection loops, treadle switches, parking access control equipment, and the guards may be used to control any toll gates, lights, or alarms. These same items may be used to indicate when a vehicle passes a checkpoint without proper authorization. Cable TV may be used to assist the guards with their surveillance of the access points.

The Traffic Control Post may be supplemented with or replaced by a card reader system and a TV camera to control access. A card reader

system would be controlled by a small computer and could be set up to monitor and control base entry through the use of access cards. The TV camera would be monitored by personnel in the Visitor Control Center.

### 3.3.3 Traffic Control at the Barricade

Static barriers should be used at the vehicle barricades to keep vehicles from circumventing the barricades and to reduce the roadway width at the barricades. Additional static barriers may be placed between lanes to simplify the operation of the barricades. If static barriers are used to isolate each lane of traffic in the blast zone, only the barricade in the lane of forced entry would need to be activated. Traffic in the other lanes could continue to pass freely. The static barriers would have to be continuous from the checkpoint past the barricades to make this operation possible. Otherwise the offending vehicle could switch lanes.

A series of small bumps in the road surface should be used in two or more locations preceeding the vehicle barricades to serve as a warning to all drivers. Warning lights should be placed above all vehicle barricades. When the barricade obstructs traffic, a red stop light should be displayed. At other times a yellow flashing light should be used. Bells, alarms, and sirens may be also used. See Figure 3-6 for a typical installation of a vehicle barricade.

### 3.3.4 Electric Detection Loops

Electric detection loops placed in saw cuts in the pavement may be used for a wide range of applications. These loops detect the presence of a vehicle by measuring the changes in electromagnetic flux in a coil of wire when the vehicle is standing or moving over the coil. These coils may be used with additional loops and access control devices like card readers to control the operation of toll gates. Two loops used with a timer can detect excessive vehicle speed or vehicles moving in the wrong direction. A single loop located in front of the barricade may be used to keep the barricade from being deployed until all cars clear the immediate area of the barricade.

### 3.3.5 Access Control Computers

Small computers used to control access to parking lots are readily available. Keys, cards, and cyphers may be issued to base personnel and may be used to gain access through an automatic gate. The cards can limit the days and/or hours that the holder may gain access. The computer can prohibit the card from being used more than once a day or the holder from passing the card to a second party. A printer will print out the names of persons entering the base or the unauthorized attempts refused by the system.

### 3.3.6 Radar Equipment

Radar equipment used by law enforcement personnel may be used to detect excessive speed. Some types of equipment may also be used to detect vehicles traveling in the wrong direction. Radar antennas may be mounted on a vertical standard, in an overhead standard, or above the TCP. The radar device must be carefully aimed to detect the speed or direction in a single lane. The antenna may need to be recessed in a housing to reduce the beam width.

## 3.4 BLAST PROTECTION

### 3.4.1 Protection From an Explosion

These references on explosive safety were provided for this study. They included the following:

| | | |
|---|---|---|
| o | DOD 6055.9 STD | DOD Ammunition and Explosive Safety Standards |
| o | TM 5-855-1 | Fundamentals of Protective Design for Conventional Weapons |
| o | TM 5-1300 | Structures to Resist the Effects of Additional Explosions |

Military personnel and facilities are to be protected from the effects of an explosion of 10,000 pounds of TNT at the access point. Both the personnel and the facilities on the main base and the occupants

of the gatehouses may be provided protection from an explosion in two ways. The distance between the explosion and the main base or the gatehouses may be increased, or the facilities may be protected to resist the effects of the explosion. In this study, it is assumed that the explosion will occur at the vehicle barrier located to deny passage to the design vehicle.

The following expected effects of an explosion were obtained from DOD 6055.9 STD.

- Inhabited Building Safety Distance - Exposure to 1.2 PSI.
  Unstrengthened buildings may sustain damage up to 5 percent of the replacement cost. Occupants of buildings are provided a high degree of protection from death or serious injury. Minor injuries would be due to flying glass and building debris. Personnel in the open are not expected to be seriously injured directly by blast. Injuries due to fragments and debris may be expected.
- Public Roads Safety Distance - Exposure to 2.3 PSI.
  Unstrengthened buildings may sustain damage up to 20 percent of their replacement cost. Occupants of buildings may suffer temporary hearing loss or injury from secondary blast effects such as building debris and the tertiary effect of displacement. Personnel in the open are not expected to be killed or seriously injured directly by blast. Injuries due to fragments and debris may be expected. Vehicles on the road should suffer little damage unless hit by a fragment or unless the blast wave causes momentary loss of control.
- Unbarricaded Blast Distance - Exposure to 3.5 PSI.
  Damage to unstrengthened buildings will be of a serious nature at 50 percent or more of their total replacement cost. There is a 10 percent charge of eardrum damage to personnel. Personnel injuries of a series nature or possible death are likely due to fragments, debris, firebrands or other objects. Vehicles will incur extensive, but not severe, body and glass

damage consisting mainly of dishing of body panels and cracks in shatter-resistant window glass.

- Barricaded Blast Distances - Exposure to 11 PSI.

  Unstrengthened buildings will suffer severe structural damage approaching total destruction. Severe injuries or death are to be expected from direct blast, building collapse, or translation. Vehicles will be heavily damaged, probably to the extent of total loss. Improperly designed barricades or structures may increase the hazard from flying debris, or may collapse in such a manner as to increase the risk to personnel and equipment. Barricading is required. Exposed structures wherein personnel exposure is signficiant may require hardening for necessary protection.

This same reference provides distances based upon the type of explosive materials and the amount of material involved for these four distances. For 10,000 pounds of TNT the following distances are given:

| | |
|---|---|
| Distance to inhabited buildings | 865 feet |
| Distance to public roads | 520 feet |
| Intraline distance, unbarricaded | 390 feet |
| Intraline distance, barricaded | 195 feet |

These distances are based upon the quantity-distance tables and are related to blast overpressures. The danger due to fragments and flying debris will extend beyond the set distances. For quantities of TNT of 100 lbs. or less, the fragment zone extends 670 feet. For quantities over 100 lbs. the fragment zone extends 1,250 feet.

In Chapter 13 of DOD 6055.9 STD the requirements to provide protection for personnel working in areas with ammunition/explosive hazards have been defined. Workers must be protected from exposures exceeding an incident blast overpressure of 2.3 psi, fragments with energies in excess of 58 ft-lb, and thermal fluxes above 0.3 calories per square centimeter per second. Sheilds complying with MIL-STD-398 may be used to provide this protection. A distance of 506 feet should

be adequate to provide the required protection for the 2.3 psi of incident blast overpressure.

DOD 6055.9 STD does not apply to the design of these access points since there are no plans to store or handle explosives at the vehicle barricade. However the above described effects may be used to describe what might happen if a quantity of explosives were set off at the vehicle barricade. If the distances to inhabited buildings and public roads is adequate for areas around ordnance storage areas, these same distances should be suitable to define the safety zone used in these concepts. However, since DOD 6055.9 STD does not apply here, the distances given for the safety zone may be reduced, but only with the knowledge that the damage due to an explosion may be more severe.

The intraline distances do not apply to the blast zone for the same reason. However, the effects expected at the unbarricaded intraline blast distance, 3.5 psi overpressure and 10 percent chance of eardrum damage, should be acceptable to apply to the checkpoint. Protected against small arms fire and thus also protected from injury due to fragments, the guards in the gatehouses should be able to respond and function after an explosion at the vehicle barricades, with a blast zone equal to the intraline distance.

### 3.4.2 Safety Zone

If a terrorist vehicle strikes a vehicle barricade, the explosive cargo of that vehicle may explode. Therefore, personnel and facilities on the military installation must be protected from the effects of such an explosion. The most effective protection may be provided by separating the access points from the main areas of the installation. This separation is called the safety zone. The safety zone is measured from the vehicle barricade to any inhabited buildings, public roads, and recreation areas. The safety zone should extend in all directions from the vehicle barricade. The distance is determined by the weight of the explosive charge and the facility or personnel to be protected. If these distances cannot be attained, it may be ne cessary to protect

inhabited facilities and personnel. Before providing blast protection, conduct an analysis as per TM 5-1300. Limited blast protection may be provided using the blast barrier concepts.

The distances of 40 $W^{1/3}$ shall be used for inhabited buildings. The distances of $24W^{1/3}$ shall be used for public roads and outdoor recreation areas. For 10,000 pounds of TNT, these distances are 865 feet and 520 feet respectively.

### 3.4.3 Blast Zone

Security personnel at the access point should also be provided blast protection if at all possible. This protection may be provided by separating the checkpoint from the vehicle barricades by a blast zone. The blast zone is measured from the barricades to the nearest traffic control post or the visitor control center. The unbarricaded distance should be used to determine the required blast zone if possible. If the required distance cannot be attained, the barricaded distance, may be used if a blast barricade is placed between the checkpoint facilities and the vehicle barricades.

The distances of $18W^{1/3}$ shall be used for the unbarricaded distance if at all possible. If a barricade is used as discussed above, the distances of $9W^{1/3}$ shall be used. For 10,000 pounds of TNT, these distances are 390 feet and 195 feet respectively.

### 3.4.4 Blast Barriers

The concepts for Cases 2 and 4 require the use of blast barriers to protect the main part of the military base since the safety zones are not large enough. The distance between the vehicle barricades, the location of the explosion, and main part of the base is not adequate to dissipate the effects of the explosion. Therefore, a blast barrier should be used to shield, deflect, or absorb the force of the blast. Several types of blast barriers may be used. They include the following:

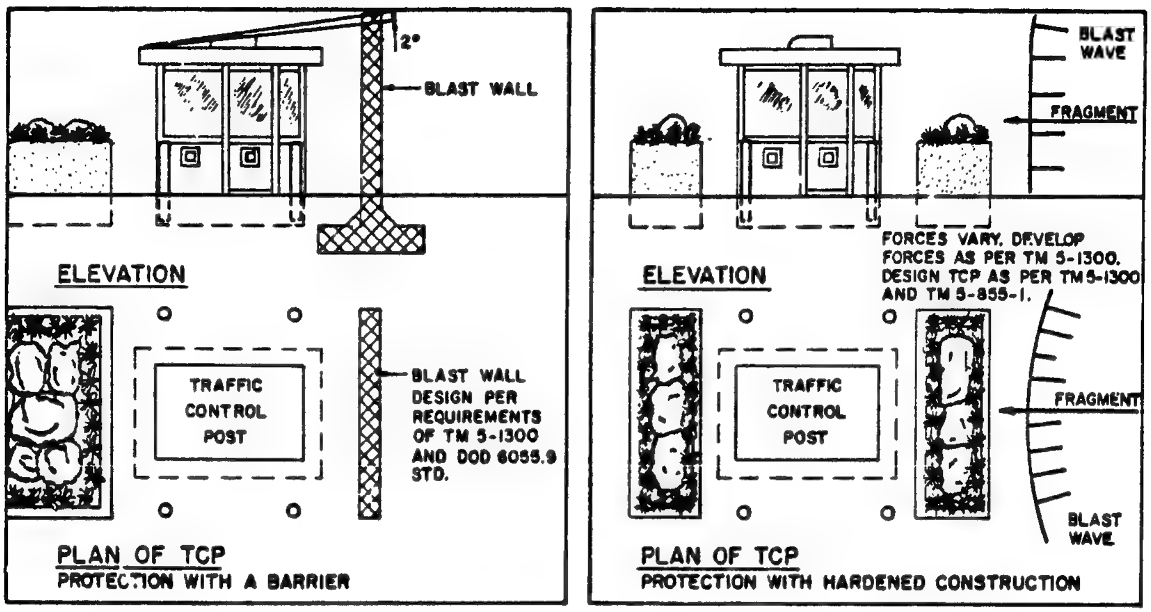



Figure 3-9 Blast Barriers and Protected Construction

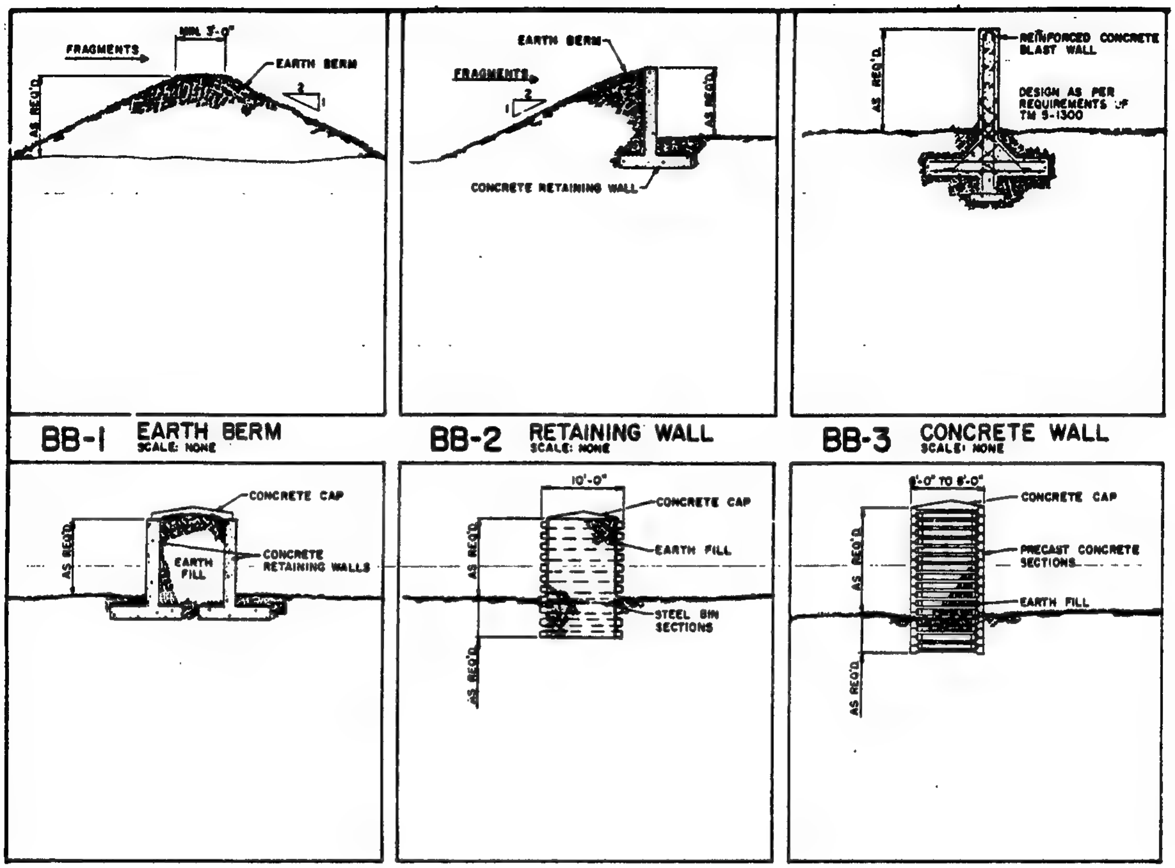



Figure 3-10 Types of Blast Barriers

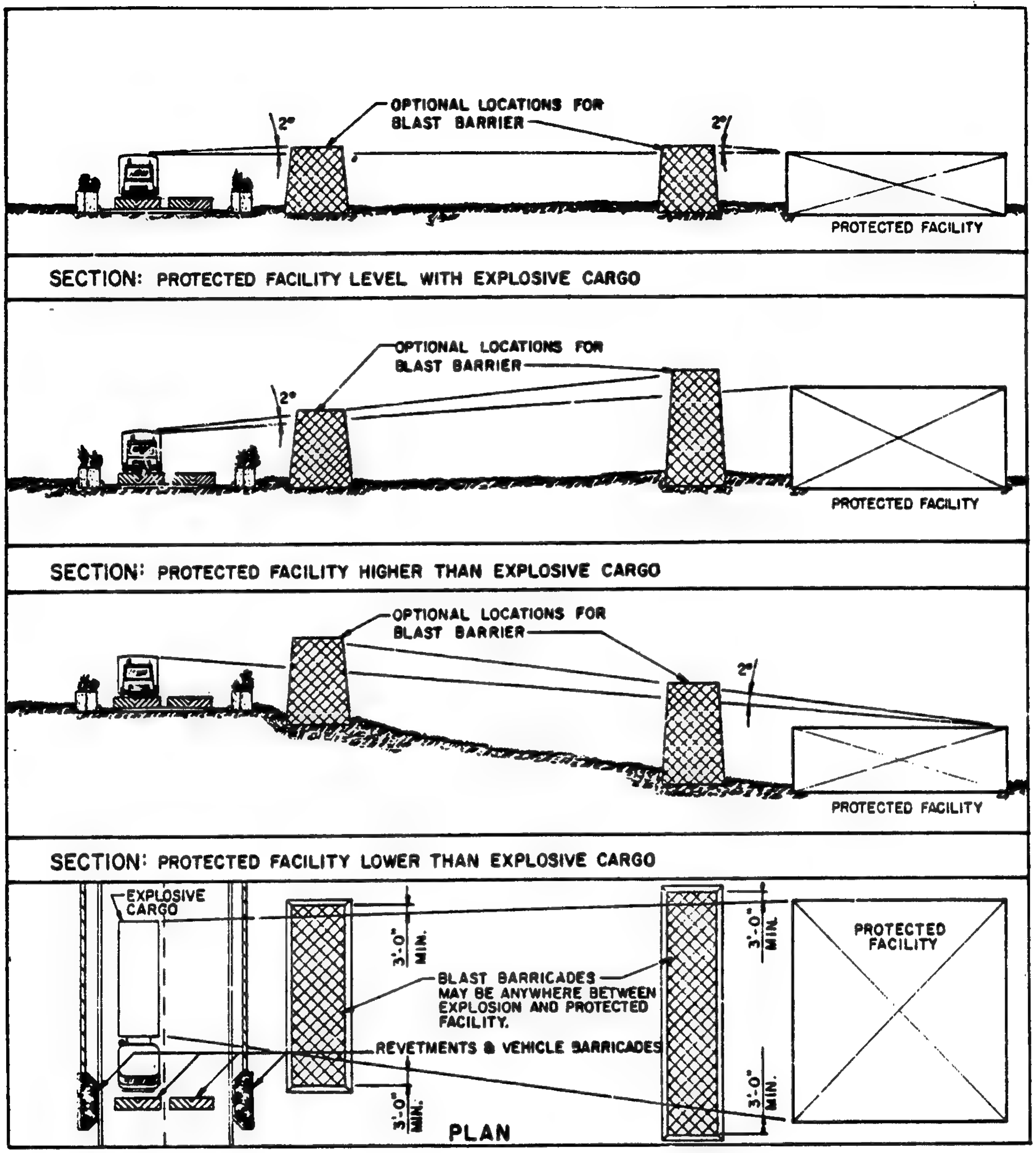



Figure 3-11 Location and Size of
Blast Barriers

- Concrete Walls: Concrete walls designed to resist the effects of the blast may be used as blast barriers.
- Earth-Filled Steel Bins: Pre-fabricated, light gauge, steel shapes assembled and filled with earth may be used to protect facilities from the effects of blasts.
- Precast concrete cribbing used like the above steel bins.
- Earth Berms, Earth Banks, and Changes in Grade: These may be used to provide blast protection.
- Blast Mats: These fabric mats may be used to contain the fragments from an explosion but not the overpressure.

Some of these blast barriers are shown in Figure 3-10. Blast barriers should be designed as per DOD 6055.9 STD. Properly constructed barricades are effective against high velocity, low angle fragments although the barriers may be destroyed in the process. Barriers also provide limited protection against blast in the immediate vicinity. They do not provide any protection against high angle fragments and are ineffective in reducing the blast pressures in the far field. Thus, every effort should be made to maintain the blast and safety distances.

In addition to providing a blast barrier, facilities on the military base may also be protected from any blast by hardening these individual facilities. If facilities are not too close to vehicle barricade, it may be more cost effective to close up windows, strengthen exterior walls and roofs, or to provide lighter blast barriers adjacent to the buildings. In other cases, the facilities that are too close may be demolished or used as an uninhabited buildings.

### 3.4.5 Protected Construction

The guards in the gatehouses may be sheltered from an explosion by protecting the gatehouses. The degree of protection required is dependent upon the distance from the explosion to the gatehouses. It is difficult to provide sufficient protection for the gatehouses if the explosion occurs adjacent to the gatehouses. The gatehouse may be protected in either or both of two methods. A blast

barrier may be imposed between the explosion and the gatehouses, allowing the gatehouses to be built in a conventional manner. Or, the gatehouses themselves could be designed to resist the effects of an explosion. See Figure 3-9. Both methods should be studied further, and the local security planners should be able to select the concept suitable for their situation.

The present "state of the art" in protective construction is adequate to protect personnel and facilities from the effects of an explosion at the vehicle barricades. Strengthening the traffic control post and visitor control center to withstand Level IV small arms fire will provide reasonable protection against fragments and building debris, but not necessarily against blast. At high levels of blast pressure, it is not possible to provide windows in the facilities at the access points. Without windows, these facilities will not be effective. Protective construction shall be designed as per TM 5-1300 and TM 5-855-1.

In Cases 2 and 4, the gatehouses are by necessity very close to the vehicle barricades where the explosion is expected to occur. In this position it will be very difficult to provide any measure of protection for the guards inside the gatehouse, without providing completely hardened gatehouses with remote surveillance equipment. It will be impossible to provide adequate protection to any guards out in the roadway.

As with the static barriers and vehicle barricades, the selection of the blast barriers should be left to the local security planners. Selection should be made after considering the threat, terrain, surrounding facilities, the amount of space available for blast barriers, and the funds available.

# 4.0 SITE CONCEPTS

The following figures illustrate nine concepts for the access points and five concepts to provide blast protection with these concepts. The figures also explain these concepts, illustrate the use of various elements and devices used to support these concepts, and summarizes the theory behind these designs.

## 4.1 GENERAL

### 4.1.1 Concepts A, B, C, and D

These four concepts are basic variations of the generalized concept with an approach zone to condition incoming traffic, a checkpoint to inspect incoming traffic, a blast zone to protect the checkpoint against a blast, and a safety zone to protect the base against that same blast. All four concepts are suitable for Design Case 1. With the proper blast protection, they would be suitable for Design Case 2. They are probably not suitable for Cases 3 and 4.

4.1.1.1 Concept A. This concept uses traffic friction devices to slow down incoming vehicles. The narrow gateways formed by the planters at the TCP make it difficult for a speeding truck to force the checkpoint. This concept could be utilized for Cases 3 and 4 under the right conditions.

4.1.1.2 Concept B. This concept uses speed detection devices to provide an early identification of speeding vehicles.

4.1.1.3 Concept C. This concept uses a series of toll gates at narrow gateways to inspect vehicles as they pass through the checkpoint. This concept could also be utilized for Cases 3 and 4 under the right conditions.

4.1.1.4 Concept D. This concept uses a large sally port to control the movements of a large group of vehicles. The double barricades and the normal traffic between them keep the terrorists from forcing their way into the base.

### 4.1.2 Concept E

Concept E provides parking space for all non-organizational vehicles outside the secure perimeter. By reducing the number of vehicles permitted to enter the installation, more time is available to stop and thoroughly check each vehicle that is allowed into the installation. Concept E is suitable for Design Case 1, and with proper blast protection, it would be suitable for Case 2.

### 4.1.3 Concept F

Concept F provides a number of sally ports with vehicle barricades that are normally deployed. Concept F is suitable for Design Case 3, and with proper blast protection, it would be suitable for Case 4.

### 4.1.4 Concepts G and H

These two concepts utilize horizontal curves to reduce the speed of incoming traffic.

4.1.4.1 Concept G. This concept uses a static barrier and sharp curves right at the public road to minimize the speed of incoming traffic. This concept is suitable for Design Case 3, and with proper blast protection, it would be suitable for Case 4.

4.1.4.2 Concept H. This concept uses sharp curves to slow down incoming traffic in front of the checkpoint and the vehicle barricade. It is suitable for Design Case 1, and with the proper blast protection, it would be suitable for Case 2.

## 4.2 GENERAL SITE LAYOUT

### 4.2.1 Zones

Each access point has four zones as follows:

a. Approach Zone: Used to sort out traffic, reduce the speed of traffic, provide stacking space for vehicles, and identify threatening vehicles.

b. Checkpoint: Used to conduct any vehicle/personnel checks.

c. Blast Zone: Used to protect the security force against an explosion at the vehicle barricade.

d. Safety Zone: Used to protect personnel and facilities on the base against the same explosion.

### 4.2.2 Elements

All concepts require the following elements:

a. Static barriers to limit the path of vehicles.

b. Traffic check post (TCP) to provide individual traffic check post (TCP) to provide individual guards protection against traffic, weather, and armed intruders.

c. Visitor control center (VCC) to house guards used to check visitors and trucks and to oversee conditions at the checkpoint.

d. Vehicle barricades to provide a final barrier at the access point against unauthorized vehicles.

### 4.2.3 Traffic Movement

The checkpoint shall accommodate the following traffic as shown in the concepts:

a. Normal incoming and departing traffic

b. Visitors

c. Truck traffic

d. Vehicles denied access

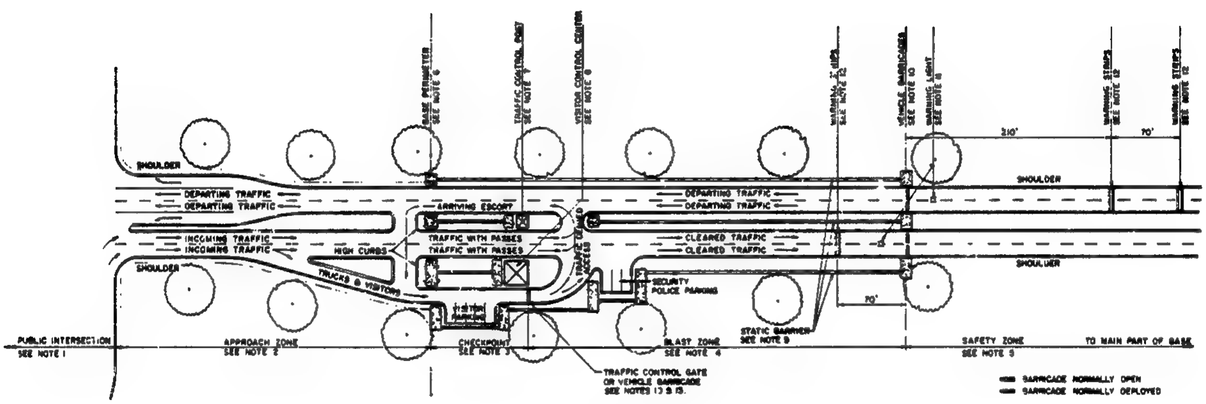



Figure 4-1 General Site Layout

e. Vehicles which require a search

f. Arriving escorts for visitors

4.2.4 Gatehouses

Each access point shall have two or more facilities for the guard force at the checkpoint, one VCC and one or more TCP's. Multiple facilities are necessary for proper surveillance of the access point and for redundancy against terrorists. An elevated control tower should be provided where necessary due to the terrain or the required level of security.

4.2.5 Vehicle Barricades

Vehicle barricades are required in the departing traffic lanes to keep a terrorist from using these lanes to gain entry to the base.

### 4.3 SITE CONCEPT A

#### 4.3.1 Premise

Slow traffic by using traffic friction devices. The narrow traffic lanes will make it very difficult for a speeding vehicle to pass without colliding with a fixed object.

#### 4.3.2 Operation

A series of friction devices are used to slow traffic. These devices include warning and speed bumps, reduction in the number and width of lanes, high curbs, lateral obstructions, and overhead obstructions. These devices slow normal traffic which will also obstruct a speeding vehicle. Traffic detection devices such as radar will identify vehicles entering the exit lanes. A separate entrance lane for visitors and trucks passes through a sally port formed by a single vehicle barricade. This barricade will be deployed normally. The vehicle barricades on the main roads are not deployed normally. Both barricades in a single roadway must be deployed to stop a vehicle. However, it is not necessary to deploy all four barricades to stop a single entering vehicle.

#### 4.3.3 Application

The concept is very flexible in application and does not depend upon high technology for its success.

#### 4.3.4 Limitations

The friction devices are potential safety hazards to normal traffic. This concept requires an approach zone long enough to accommodate backed up traffic.

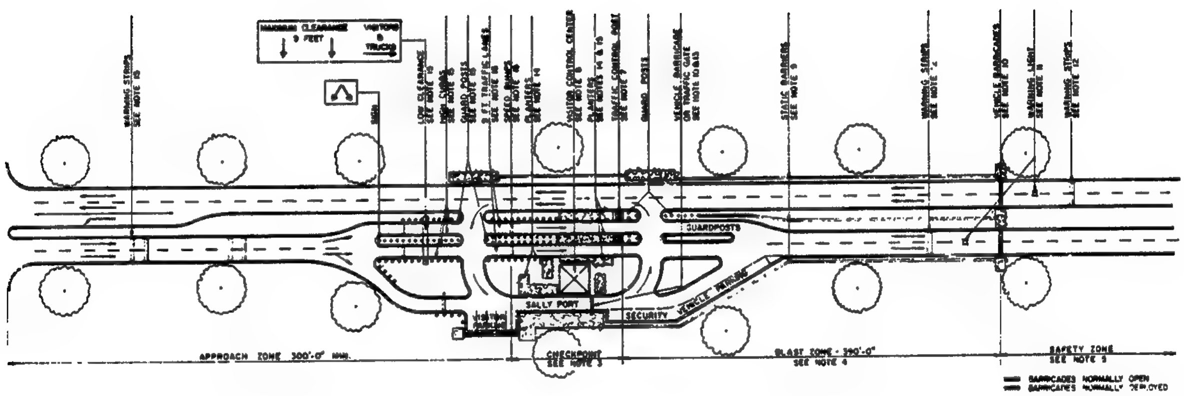



**Figure 4-2 Site Concept A**

## 4.4 SITE CONCEPT B

### 4.4.1 Premise

Use speed detectors to identify threatening vehicles and sound the alarm.

### 4.4.2 Operation

Devices, such as radar, detection loops, or light beams, detect vehicles speeding or entering the exit lanes and automatically deploy relatively lightweight traffic control gates. If the vehicle crashes through the first gate, an alarm will sound. At the guard's option, the vehicle barricades farther down the road may also be deployed. The purpose of the traffic control gates, which are open normally, is to provide a barrier whose penetration identifies forceful entry intent, but which will not be deadly to drivers, such as speeders or mischievous teenagers, who do not intend forceful entry. The vehicle barricades are deployed as described for Concept A.

### 4.4.3 Application

A relatively long approach zone will be required for vehicle speed adjustment prior to speed monitoring and for speed monitoring.

### 4.4.4 Limitations

Because signage is not as reliable as physical features for slowing traffic, false alarms are probable.

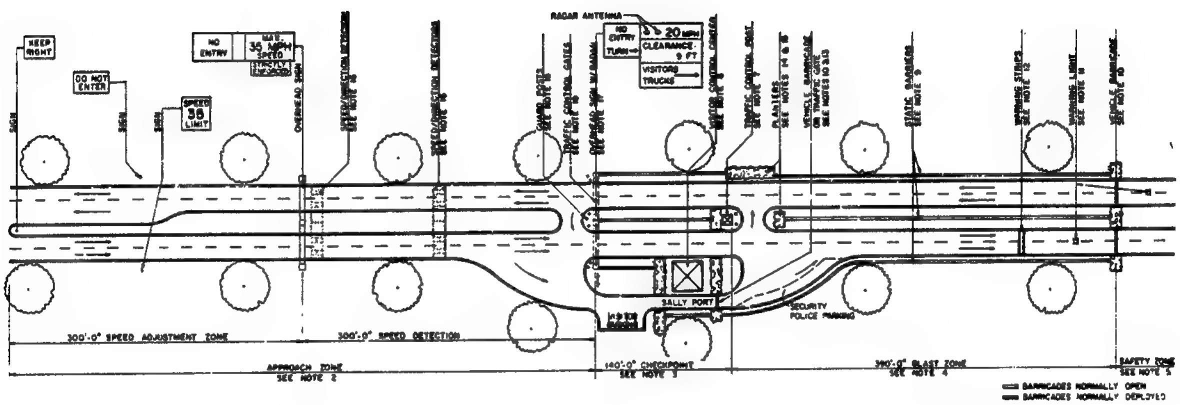


Figure 4-3  Site Concept B

## 4.5 SITE CONCEPT C

### 4.5.1 Premise

Increase flow of traffic with multiple "toll booth" type checkpoints and some lanes reversible to accommodate rush hour traffic in both directions. Vehicle barricades are activated when a "toll booth" gate is violated.

### 4.5.2 Operation

Incoming traffic is separated by those vehicles with or without passes. Those without passes are cleared through a sally port formed by a single vehicle barricade. Those vehicles with passes use multiple lanes which each have a toll gate activated by the guard in the traffic control post. The traffic control posts could be replaced by card readers, closed circuit television, or some other device monitored from the visitor control center. The vehicle barricades are deployed by guards when a toll booth gate arm is violated. Toll booth gates are provided in the exit lanes to activate the vehicle barricades when a forced entry occurs via the exit lanes. The exit lane toll gates are automatically raised on demand for exiting vehicles. To make the center lanes reversible, the lane markings must be flexible. On the public side of the checkpoint, plastic cones or some other low cost method may be used to properly channel traffic. On the installation side of the checkpoint, the incoming and exiting lanes must be separated by a vehicle barrier, such as a row of operable bollards. Otherwise all vehicle barricades must be deployed when a forced entry occurs.

### 4.5.3 Application

The concept is applicable to many different situations because of its flexibility in modifying the number of lanes.

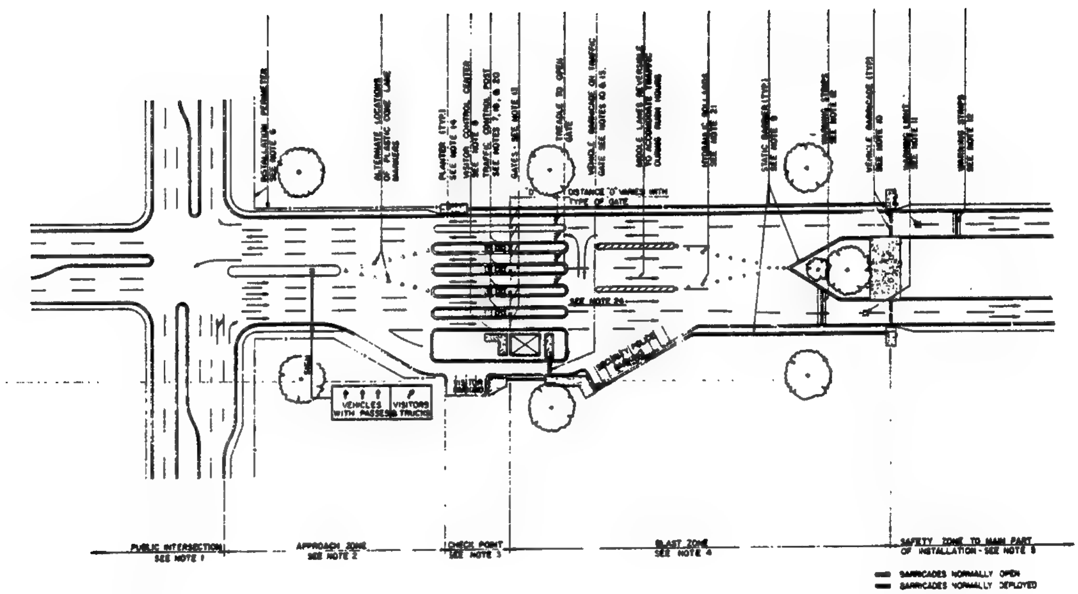



Figure 4-4  Site Concept C

4.5.4 Limitations

The multiple lanes require a large number of security personnel or the technology to replace them.

## 4.6 SITE CONCEPT D

### 4.6.1 Premise

Eliminate the window of vulnerability occurring when the vehicle barricades are open by using a traffic holding area. The traffic holding area is used to hold enough cars to block passage along the roadway. The traffic holding area shall hold a large number of cars to minimize the restriction to flow during rush hours.

### 4.6.2 Operation

Incoming vehicles first clear the checkpoint area and then enter the traffic holding area. The vehicle barricades at the end of the traffic holding area are deployed, blocking passage to all incoming traffic. When enough cars are in the traffic holding area to prevent a terrorist from forcing his way down the road, the traffic gates at the beginning of the traffic holding area are closed and the vehicle barricades are opened. While the traffic holding area empties, traffic will back up behind the traffic gates forming a new barrier against the terrorists. When the traffic holding area is empty of vehicles, the barricades are closed, the traffic gates are opened, and the traffic advances to the vehicle barricades to repeat the process. Outgoing traffic goes through a similar process when leaving the base. If a terrorist forces his way past the traffic gates, the vehicle barricades would be immediately closed to limit the advance of the terrorist. During periods of heavy traffic, the same effect may be achieved by using only the traffic lights to limit traffic movement. Incoming trucks and visitors use a separate lane at the checkpoint to avoid tying up a normal lane of traffic. Visitors and trucks may rejoin the normal flow of traffic in the traffic holding area or use an optional lane bypassing the traffic holding area. This separate lane may also be used by emergency vehicles. If additional static barriers are used to separate all lanes of traffic, the traffic gate and vehicle barricade in each lane may be operated independently of the gates and barricades in

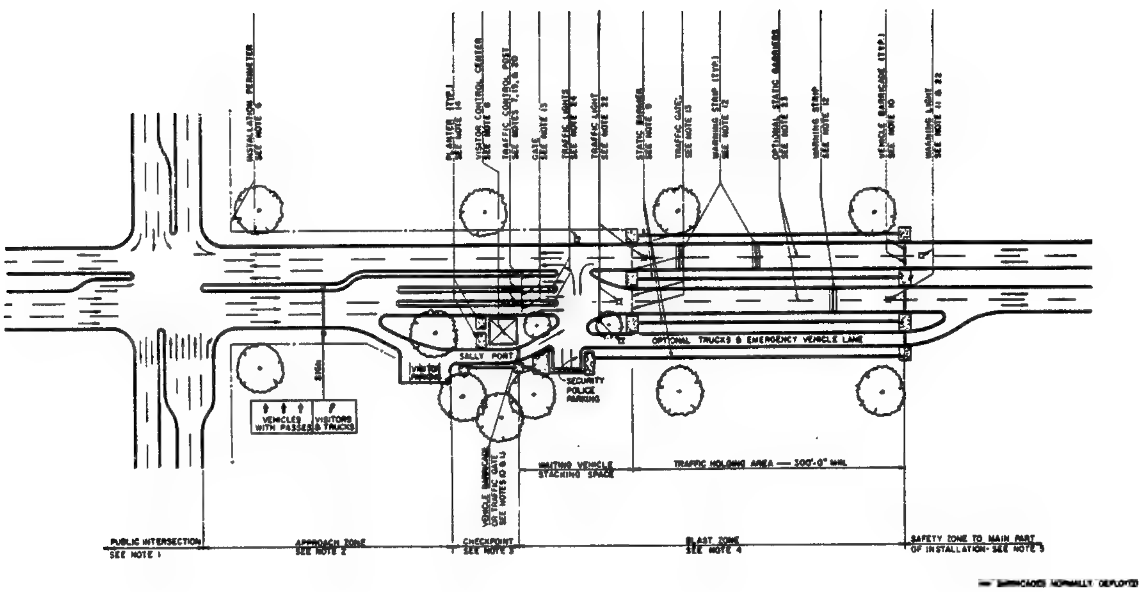



Figure 4-5 Site Concept D

the other lanes. This method will provide greater flexibility during various levels of traffic.

### 4.6.3 Application

This concept requires a long distance between the checkpoint and the main part of the installation.

### 4.6.4 Limitations

The multiple lanes require a large number of security personnel or the technology to replace them.

## 4.7 SITE CONCEPT E

### 4.7.1 Premise

Reduce vehicular access to the installation to such a small number of vehicles that each one can be stopped and inspected in a sally port.

### 4.7.2 Operation

Staff and visitors park their private vehicles outside the installation perimeter and take shuttle buses onto the installation. To ride the bus, a person must have an installation access pass. The vehicles allowed on the installation can be limited to shuttle buses and delivery trucks. Official vehicles, vehicles driven by the handicapped, private vehicles owned by persons living on the installation, car pool vehicles, and vehicles entering the installation at times other than rush hour might also be allowed on the installation, depending on the amount of traffic, severity of the security threat, or practicality of shuttle bus service. The use of toll gates and card readers to allow access to preapproved vehicles is an optional addition to this concept.

The two vehicular barricades which form the secondary checkpoint are normally deployed.

### 4.7.3 Application

This concept does not require a long approach zone, but it does require space for parking lots.

### 4.7.4 Limitations

Shuttle bus service may not be feasible economically, particularly at a large, sprawling, existing installation. Minimal blast protection is offered to security personnel at secondary checkpoint.

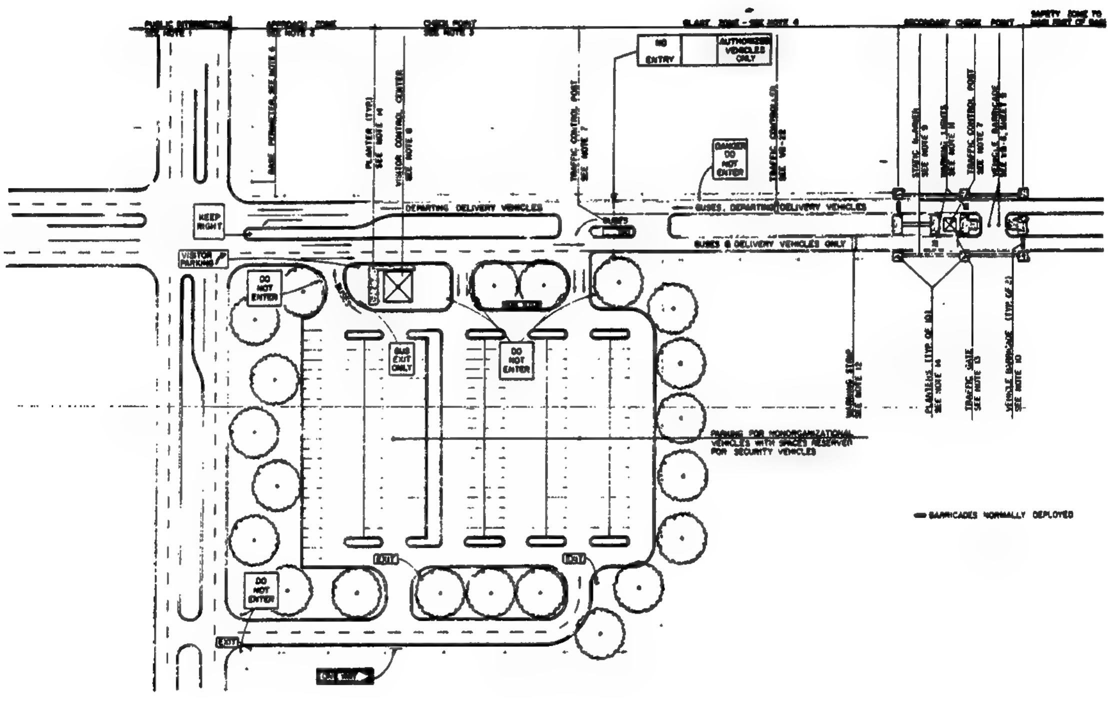



Figure 4-6 Site Concept E

4.7.5 Note

Vehicle barricades must be capable of preventing a terrorist from tailgating a vehicle authorized entry. If the barricade selected is not capable of preventing tailgating, the barricades should be used in each entry/exit lane to form a true sally port.

When an installation requires a high level of security, the barricades should be used in pairs to form sally ports for each entry/exit lane.

## 4.8 SITE CONCEPT F

### 4.8.1 Premise

Increase the number of incoming lanes and traffic control posts so that each vehicle can be stopped and inspected.

### 4.8.2 Operation

The vehicle barricade in each entrance and exit lane must be deployed at all times because there would not be sufficient time for deployment after identification of a threat. The toll gate in each entrance lane is a safety feature that defines the stopping point for inspection and stops a vehicle before it collides with the barricade. The vehicle barricades may be opened to permit greater traffic flows if security conditions permit it.

The optional separate lane for incoming visitors and trucks improves the efficient flow of traffic through the other lanes.

### 4.8.3 Application

This concept is well suited to installations with minimal distance between the public road and the checkpoint.

### 4.8.4 Limitations

This concept requires a large number of expensive vehicular barricades which are subject to frequent operation (heavy wear and tear). Minimal blast protection is offered to security personnel.

### 4.8.5 Note

Vehicle barricades must be capable of preventing a terrorist from tailgating a vehicle authorized entry. If the barricade selected is not capable of preventing tailgating, two barricades should be used in each entry/exit lane to form a true sally port.

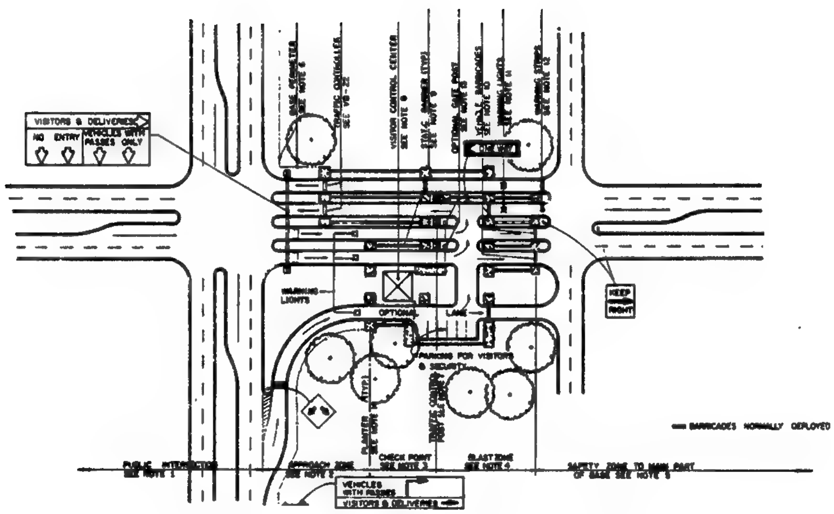


Figure 4-7  Site Concept F

When an installation requires a high level of security, the barricades should be used in pairs to form sally ports for each entry/exit lane.

## 4.9 SITE CONCEPT G

### 4.9.1 Premise

Use static barriers to create a sharp turn to force a vehicle to slow down before entering the checkpoint.

### 4.9.2 Operation

Vehicles with passes are separated from those without passes. Gates at the checkpoint are optional. Vehicle barricades are deployed by guards or when a toll gate is broken by a speeding vehicle. The exit lane gate is automatically raised on demand for an exiting vehicle.

### 4.9.3 Application

This concept is well suited to a situation where there is a short distance between the public road and the checkpoint. The blast zone may be reduced in length if sally ports are formed in each lane by adding additional barricades and the guards are protected from a blast.

### 4.9.4 Limitations

The barrier at the public road limits flexibility for entering and exiting the installation.

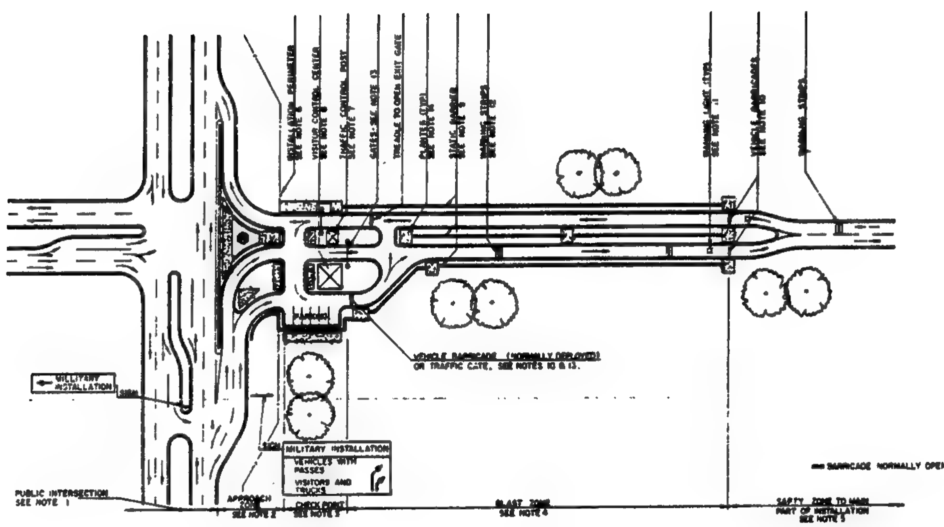



Figure 4-8  Site Concept G

## 4.10 SITE CONCEPT H

### 4.10.1 Premise

Use curves to slow traffic before reaching the checkpoint and before reaching the vehicle barricades.

### 4.10.2 Operation

Traffic is slowed before reaching the checkpoint so that guards have time to identify a threatening vehicle and deploy the vehicle barricades. The curve at the vehicle barricades and the static barrier which prevents crossing over between exit and entrance lanes, minimize the threatening vehicle's impact speed at the barricade.

### 4.10.3 Application

This concept requires a relatively long distance between the public road and the checkpoint. It requires a similar distance between the checkpoint and the main base.

### 4.10.4 Limitations

The concept uses a fairly large land area.

## 4.11 VEHICLE APPROACH

There are significant advantages to be gained in controlling the speed of the approaching vehicle. If the design vehicle is not allowed to reach the barricade traveling at a high rate of speed, a more economical barricade may be used and the probability of stopping the vehicle are significantly increased. If a vehicle's speed can be reduced by 50 percent, then its kinetic energy is reduced by 75 percent.

Law-abiding drivers will reduce their speed when approaching the checkpoint in response to warning strips or speed bumps in the road: speed limit, caution, or stop signs alongside the road; flashing lights along the road; or changes in the width of the road or road surface.

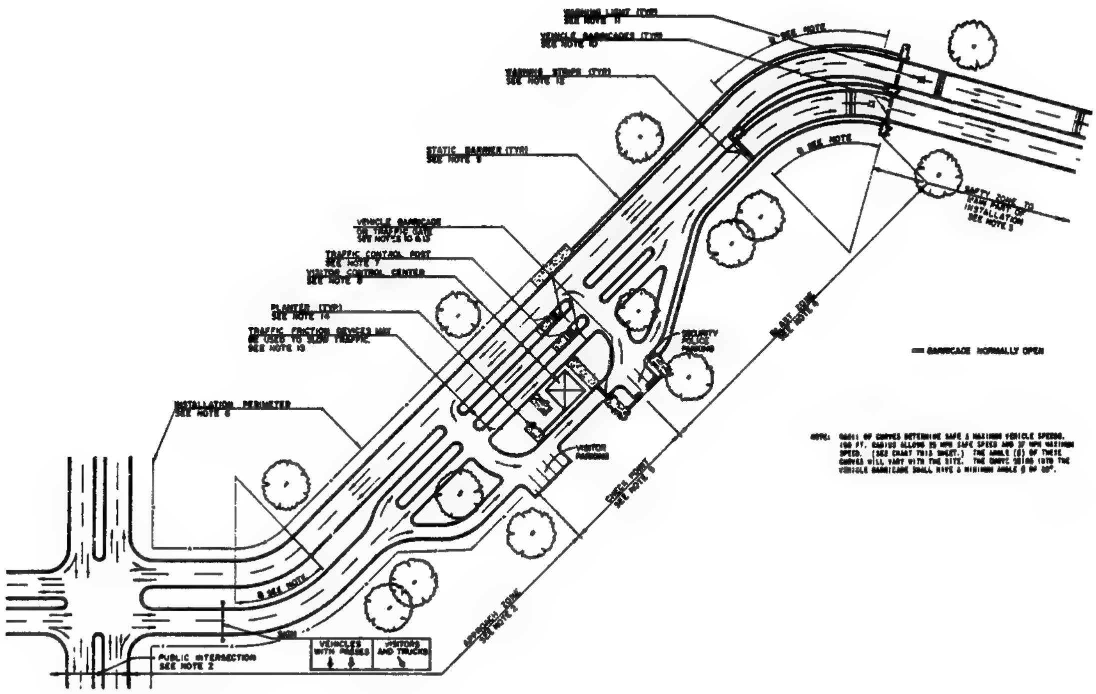



Figure 4-9 Site Concept H

However, these measures are not sufficient to force the determined terrorist to slow down. More forceful ways to make the driver of any vehicle slow down include the use of horizontal and vertical curves in the road, stringent reductions in the road widths, and traffic congestion in the road ahead. To use these measures successfully, it is necessary to keep the driver on the road and prevent him from going around these hazards or taking ahort cut across any open terrain.

The table below may be used to select horizontal curves in the road before the checkpoints and the vehicle barricades. The critical R curves are not calculated using a super-elevation. In addition, if these curves were given a reverse super-elevation, a speeding vehicle would more likely skid out of control.

Vertical curves may be effective in controlling the speed of approaching vehicles. When the checkpoint is located at the top of a steep grade, approaching vehicles, especially heavy trucks, can only approach the checkpoint at reduced speeds. For similar reasons, the checkpoint should not be located at the bottom of a hill. Heavy trucks and other vehicles will be more difficult to stop if they are able to build up speed coming down a hill.

When sharp horizontal curves, steep vertical curves, and/or traffic friction devices are used, signs must be posted to warn approaching drivers of the upcoming traffic hazards and to establish the safe vehicle speeds. Signs shall also caution that speed limits will be strictly enforced.

Where possible, incoming drivers should curve to the left as they approach the checkpoint. Left-hand curves give the guards at the checkpoint a better view of incoming vehicles and their drivers and makes it easier for them to identify which vehicles are authorized entry. Left-hand curves also expose the driver of a terrorist vehicle to the guards' line of fire and any passengers of such a vehicle are forced to fire past the driver out of the left side windows.

Table 4-1 Approach Curves

TURNING RADIUS (R)

| VEHICLE SPEED | RECOMMENDED | SAFE (R) | CRITICAL R |
|---|---|---|---|
| 15 MPH | 90 FT | 50 FT | 25 FT |
| 20 | 160 | 90 | 40 |
| 25 | 255 | 150 | 70 |
| 30 | 375 | 230 | 100 |
| 35 | 525 | 300 | 135 |
| 40 | 710 | 430 | 175 |
| 45 | 930 | 550 | 225 |
| 50 | 1190 | 690 | 275 |
| 55 | 1495 | 840 | 335 |
| 60 MPH | 1845 | 1040 FT | 400 FT |

USE OF TABLE

1. SELECT DESIRED VEHICLE SPEED.

2. SELECT R BETWEEN RECOMMENDED R AND SAFE R.

3. NOTE VEHICLE SPEED OF CRITICAL R CORRESPONDING TO R SELECTED IN STEP 2.

4. IS VEHICLE SPEED FOUND IN STEP 3 ACCEPTABLE?

5. IF NOT, SELECT A SHORTER R AND REPEAT STEPS 3 & 4.

RECOMMENDED R BASED ON AASHO RECOMMENDATIONS FOUND IN HIGHWAY ENGINEERING, TABLE 8-10.

SAFE R BASED ON GUIDE VALUES FOR EXIT RAMPS FOUND IN STANDARD HANDBOOK FOR CIVIL EINGINEERS, TABLE 16-24.

CRITICAL R BASED ON A 0.6 COEFFICIENT OF SIDE FRICTION.

APPROACH CURVES ASSUMED TO BE FLAT, I.E., NO SUPERELEVATION.

## 4.12 TRAFFIC VOLUME

The following guidelines may be used to determine the required number of entry/exit lanes required at the checkpoints. The volume of traffic on a road is affected by the terrain, road width, location of obstructions along the road, and the percentage of trucks in the

traffic. With level terrain and 5 percent of the traffic being trucks, the following traffic volumes may flow along a one-way road:

| ROADWAY | VEHICLES/HOUR |
|---|---|
| o 10 ft lane with no obstructions within 6 ft of the edges of the roadway | 1730 |
| o 10 ft lane with obstructions on both sides 4 ft from the edges of the roadway | 1690 |
| o 10 ft lane with obstructions on both sides 2 ft from the edges of the roadway | 1630 |
| o 10 ft lane with obstructions on both sides at the edges of the roadway. | 1400 |
| o 9 ft lane with obstructions on both sides at the edges of the roadway. | 1200 |

The volume of traffic actually passing a tcp will be considerably reduced from those volumes listed above, if any type of security check is performed. Assuming level terrain, no trucks, and a 10 ft roadway with obstructions on both sides at the edges of the roadway, the following volumes of traffic may be expected to pass a tcp in one lane of traffic:

| SECURITY LEVEL | VEHICLES/HOUR |
|---|---|
| o NO SECURITY CHECK | 1400 |
| o VEHICLE TAG CHECK | 1000-1200 |
| o PERSONNEL ID CHECK | 400-600 |
| o COMPLETE INSPECTION | LESS THAN 60 |

WITH TRAFFIC CONTROL DEVICES, THE FOLLOWING VOLUMES MAY BE EXPECTED:

| CONTROL DEVICE | VEHICLES/HOUR |
|---|---|
| o TOLL GATE-FREE PASSAGE WITH GATE CLOSING AFTER EACH VEHICLE | 250 |
| o TOLL GATE & CARD READER | 150 |

4.13 GENERAL NOTES

The following notes are referenced in the preceding figures.

1. Public Intersection - The public intersection occurs at the property line of the base. The intersection may occur as a 4-way intersection between two major roads. A 3-way intersection between the base road and a through road, or an extension of a side road.

2. Approach Zone - The length of the approach zone will vary due to the land available. The speed of oncoming vehicles, the amount of weaving required to sort out incoming traffic, and the means used to control the speed of incoming traffic, the length of this zone, and the volume of traffic will determine the number of lanes required to provide adequate stacking room to minimize congestion in the public intersection.

3. Checkpoint - This area includes the traffic control post (TCP), the visitor control center, and the secions of road used to check entry passes and inspect vehicles.

4. Blast Zone - The blast zone is the distance between the checkpoint and the vehicle barricade. This distance is necessary to protect the guards at the checkpoint from an explosion at the vehicle barricade. The distance is determined by the weight of the explosive charge. Special protection for the guards may be necessary if these distances cannot be obtained.

This distance must also be great enough to provide adequate reaction time for the guards and barricades to respond to a forced entry. If this distance is not great enough, then the vehicle barricades should be deployed except when authorized vehicles are allowed to pass. If this distance becomes too great, the guards at the checkpoint may not be able to contol the activities of persons stopped at the vehicle barricade.

5. Safety Zone - The safety zone is the distance from the vehicle barricade and any inhabited building, public road, or outdoor recreation area. This distance extends in all directions around the vehicle barricades and is necessary to protect base personnel from an explosion at the vehicle barricade. The distance is determined by weight of the explosive charge and the facility or personnel to be protected. If adequate distance is not available, it may be necessary to protect facilities against the effects of a blast.

6. Base Perimeter - The base perimeter shown on these drawings is the outermost secured perimeter of the base. This perimeter must be secured against the identified threat. If the base perimeter at these access points is not capable of excluding the same threat as the access points, additional static barriers may be required to keep the threat on the roadway.

7. Traffic Control Post (TCP) - The guard(s) in a TCP are only able to observe two to four lanes of traffic. Additional TCP's will be required if there are additional lanes of traffic, if the volume of traffic is heavy during periods of the day, or if the level of security requires close checking of incoming traffic. The TCP provides the guards a position secure against the hazards of traffic and small arms fire. One TCP should be provided to the left of each incoming lane of traffic for the best protection.

8. Visitor Control Center (VCC) - The visitor control center is the control center for the access point. The controls for the intrusion detection equipment, surveillance monitors, vehicle barricades, security lighting, and the communication equipment for the access point are located in this facility. Personnel in the visitor control center also handle the special cases of visitors and trucks trying to gain entry to the installation.

9. Static Barriers - Static barriers may be natural features of the terrain or manmade devices to prohibit the passage of a vehicle. In these concepts, these barriers are identified as static barriers without specifying any specific device. Specific devices shall be selected after considering the threat, the local conditions, and their relative costs.

10. Vehicle Barricades - Various vehicle barricades are currently being manufactured. Specific vehicle barricades shall be selected after considering the threat, the local conditions, and their relative costs. The force of any vehicle ramming most of these devices at speeds above 20 mph may be lethal to the occupants of that vehicle. Therefore, extreme caution must be exercised to ensure that these devices are not activated at the wrong time.

11. Warning Lights - Warning lights shall be placed above all vehicle barricades. When the barricade obstructs traffic, a red stop light shall be displayed. At other times a yellow flashing light shall be used.

12. Warning Strips - A series of small bumps in the road surface shall be used in two or more locations preceding the vehicle barricade to serve as a warning to all drivers.

13. Gate - A gate, crash beam, or vehicle control arm may be used to define the stopping zone for vehicles going through the checkpoint. The gate is not expected to prevent passage of a high speed vehicle. However, forcing passage through the gate may be used to activate a visual or audible alarm or even the vehicle barricades.

14. Planters - Planters may be used at the termination point of static barriers to provide them with additional strength. Planters themselves may be used as static barriers and to protect the tcp and visitor control center against being rammed by a vehicle.

15. Friction Devices - Contrary to good highway design, a series of devices may be used to impede the flow of vehicles moving along a highway. These friction devices include:

    Narrow traffic lanes
    High curbs
    Side obstructions at the edge of the pavement
    Low overhead obstructions
    Speed bumps, dips, warning strips or breaks in the pavement

16. Speed/Direction Detectors - Several electronic devices including radar, detection loops and light beams may be used to detect vehicles traveling at excessive speeds or vehicles traveling in the wrong direction.

17. Radar Detection Equipment - Radar antennas may be mounted on a vertical standard, in an overhead standard or above the TCP. The radar device must be carefully aimed to detect the speed or direction in a single lane. The antenna may need to be recessed in a housing to reduce the beam width.

18. Traffic Control Gates - These toll gates are normally open. When the speed/direction detectors identify an improper approach, the gates in those lanes will close. If the gates are forced, the oncoming vehicle will have declared the intent to force an entry to the base.

19. Access Control - The traffic control post may be supplemented with or replaced by a card reader system or TV camera to control access. A card reader system would be controlled by a small computer and could be set up to monitor and control base entry through the use of access cards. The TV camera would be monitored by personnel in the visitor control center.

20. Overhead Obstruction - An overhead obstruction may be used to separate trucks from automobiles based upon the amount of headroom each vehicle needs to pass under an obstruction. This obstruction or portal may also be used to mount signs, traffic lights, and entry control equipment.

21. Lane Control - The vehicle barricades must be operated in one of two methods. All four barricades may be operated together if a vehicle violates the checkpoint. This operation would prevent a terrorist from forcing his way through the exit lanes and then avoiding the vehicle barricades in the exit lanes by weaving to the left to slip by the barricades in the entry lanes. If operable bollards or a similar type of vehicle barricade were used to provide a positive barrier to keep vehicles from switching from exit to entry lanes, only the two vehicle barricades on the violated side would have to be activated. The positive barrier could also be a detection device such as a light beam to detect when a vehicle crosses over. In that event, the second set of barricades would have to be activated.

22. Traffic Lights - These traffic lights may be used to control the flow of traffic during rush hours instead of the barricades. During rush hour traffic, it is assumed that the volume of traffic will be adequate to prevent a terrorist from forcing his way past lines of vehicles on a narrow road.

23. Lane Dividers - Additional static barriers may be used to separate individual lanes of traffic. When lane dividers are used, only one vehicle barricade would have to be activated, thus permitting traffic to flow on all other lanes. Lane dividers also make it possible to close lanes during off hours when the traffic is very light.

24. Visitors Denied Admission to the installation must cross several lanes of incoming traffic. They will require assistance to be able to quickly exit from the access point, especially during rush hour traffic. This assistance may be provided in several ways:

    a. Security personnel work together to properly direct traffic.
    b. Traffic lights are used to stop normal traffic while the visitor leaves.
    c. Traffic gates are used to stop normal traffic.

25. Sirens, Air Horns, Flashing Lights, Etc. Should be used as alarm devices when an illegal entry is detected.

## 4.14 BLAST CONCEPTS

### 4.14.1 General

4.14.1.1 Concept BA. This concept provides the installation blast protection by protecting existing buildings with hardened construction or blast barriers and by removing or converting existing facilities.

4.14.1.2 Concepts BB and BC. These two concepts provide blast protection for the base by placing the access point within a blast chamber. Concept BB locates the access point and its blast chamber along the perimeter of the installation. Concept BC locates the access point and its blast chamber in the heart of the installation.

4.14.1.3 Concept BD. This concept locates only the vehicle barricades in a blast chamber to provide blast protection for both the checkpoint and the installation.

4.14.1.4 Concept BE. This concept locates the vehicle barricades outside of the installation using a blast wall complete with blast doors that are nromally closed.

4.14.1.5 Concept BF. This concept integrates the gatehouse at the checkpoint, the vehicle barricade and static barriers, and the blast barriers into a single structure to control access to the installation and to provide blast protection. This concept is suitable for Design Case 4.

### 4.14.2 Concept BA

4.14.2.1 Premise: Protect individual facilities against the effects of a blast at the vehicle barricade.

4.14.2.2 Method. The following methods may be used to protect buildings within the safety zone:

- o Remove or demolish them.
- o Convert them to uninhabited buildings.
- o Harden the building by removing the windows and strengthening the structure and exterior walls.
- o Build a blast barrier to protect the building against fragments from the blast. This method may not protect the building from overpressure.

4.14.2.3 Application: This concept will work if the buildings are scattered, few in number, and at long distances from the access points.

4.14.2.4 Limitations: This concept will not be effective on a densely developed installation.

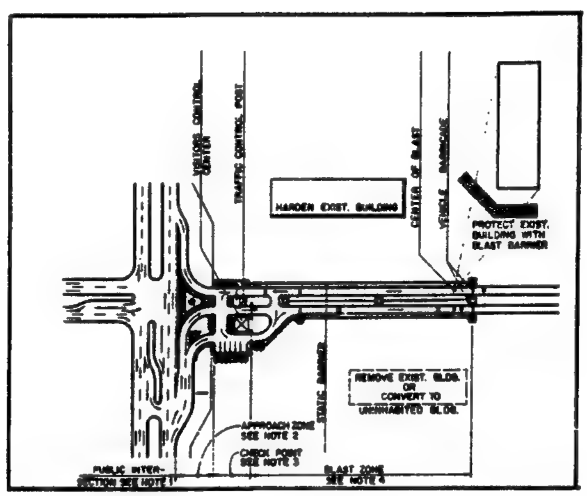



Figure 4-10 Blast Concept BA

4.14.3 Concept BB

4.14.3.1 Premise: Separate access point from the installation by a single, long blast wall parallel to the base perimeter.

4.14.3.2 Method: Provide the access point along the public road and provide a blast wall between the access point and the main base.

4.14.3.3 Application: May be used when there is adequate open space along the perimeter of a military installation.

4.14.3.4 Limitation: Tall barriers will be required to protect multi-story buildings. This concept provides protection against fragments but not necessarily against the overpressure of a blast.

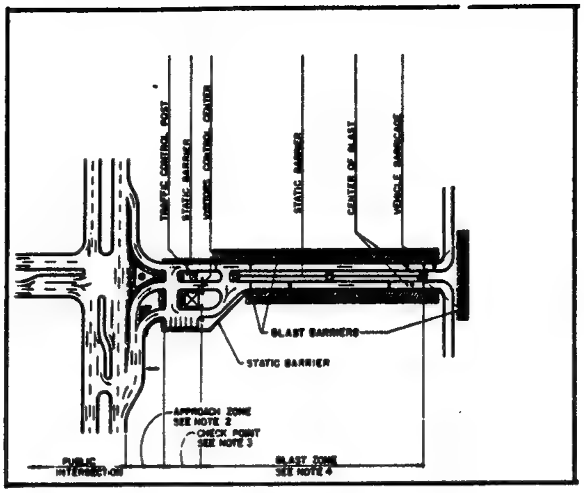
4.14.4 Concept BC

4.14.4.1 Premise: Surround the access point with blast barriers.

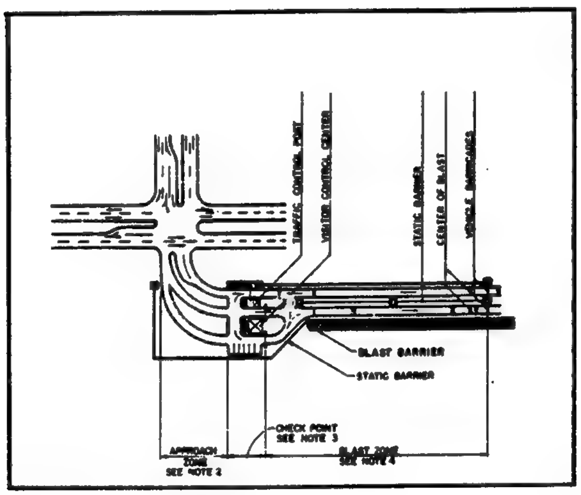
4.14.4.2 Method: Provide blast barriers alongside the roads at the vehicle barricades.

4.14.4.3 Application: May be used when there is adequate open space within the main part of the base to insert the access point and blast barriers.

4.14.4.4 Limitation: Tall barriers will be required to protect multi-story buildings. This concept provides protection against fragments but not necessarily against the overpressure of a blast.




Concept BB




Concept BC

Figure 4-11 Blast Concepts BB and BC

4.14.5 Concept BD

4.14.5.1 Premise: Use blast barricades to protect both the checkpoint and the main part of the base.

4.14.5.2 Method: Provide blast barriers between the vehicle barricades and the checkpoint as well as between the barricades and the main part of the base.

4.14.5.3 Applications: May be used when there is inadequate space for both the blast zone and the safety zone.

4.14.5.4 Limitations: Guards at the checkpoint are not able to observe activity at the barricades. Tall barriers will be required to protect multi-story buildings. This concept provides protection against fragments but not necessarily against the overpressure of a blast.

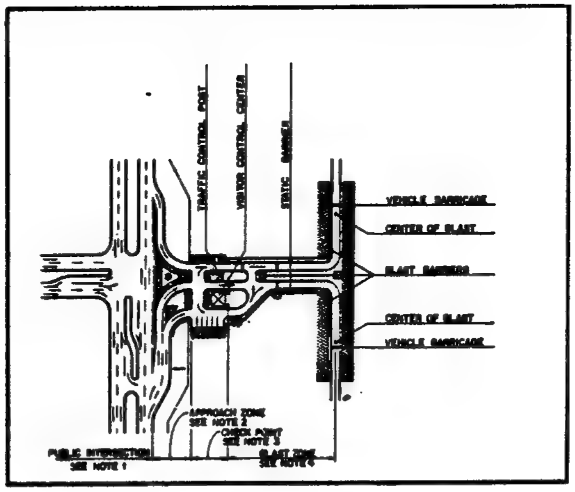
4.14.6 Concept BE

4.14.6.1 Premise: Use blast doors in a blast wall to provide protection for the installation.

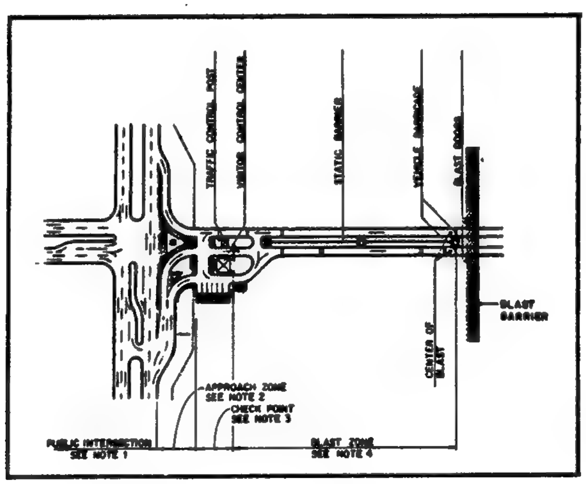
4.14.6.2 Method: Place a blast wall between the vehicle barricades and the main part of the base. Use blast doors in that wall to provide base access. Blast doors will be closed normally.

4.14.6.3 Application: This concept will work well if the volume of traffic through the checkpoint is very low.

4.14.6.4 Limitation: Tall barriers will be required to protect multi-story buildings. This concept provides protection against fragments but not necessarily against the overpressure of a blast.




Concept BD




Concept BE

**Figure 4-12 Blast Concepts BD and BE**

### 4.14.7 Concept BF

4.14.7.1 Premise: Use a protected traffic control center within the blast barrier.

4.14.7.2 Method: Use sharp turns to control vehicle approach speeds. Traffic control center is part of the static barrier and blast barrier. Vehicle barricades are behind a second curve. Traffic control center is not in line of sight of the explosion, but partially protected by the blast barrier.

4.14.7.3 Application: Useful when both blast and safety distances are limited.

4.14.7.4 Limitations: Guard cannot see vehicle barricade.

## 4.15 BLAST & SAFETY ZONES

### 4.15.1 Safety Zone ($40W^{1/3}$ AND $24W^{1/3}$)

If a terrorist vehicle strikes a vehicle barricade, the explosive cargo of that vehicle may explode. Therefore, personnel and facilities on the military installation must be protected from the effects of such an explosion. The most effective protection may be provided by separating the access points from the main areas of the installation. This separation is called the safety zone. The safety zone is measured from the vehicle barricade to any inhabited buildings (inhab. bldg.), public roads (pub. road), and recreation areas (pub. road). The safety zone shall extend in all directions from the vehicle barricade. The distance is determined by the weight of the explosive charge and the facility or personnel to be protected. Refer to Table 4-2 below for these safety distances. If the distances below cannot be attained, it may be necessary to protect inhabited facilities and personnel. Before providing blast protection, conduct an analysis as per TM 5-1300. Limited blast protection may be provided using the blast barrier concepts.

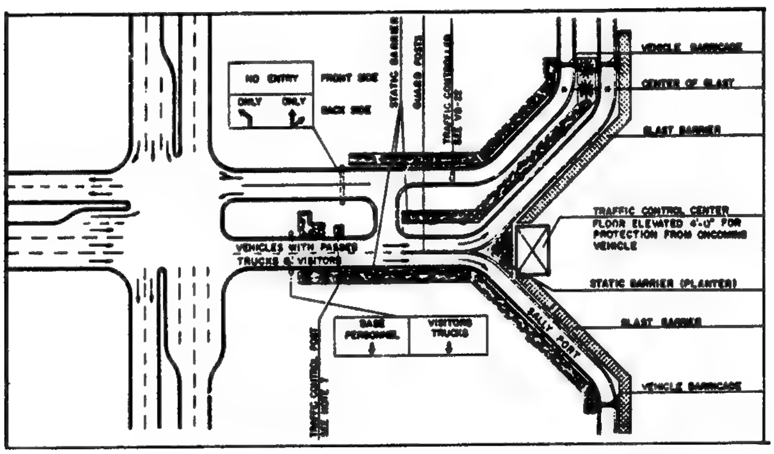



Figure 4-13 Blast Concept BF

### 4.15.2 Blast Zone ($18W^{1/3}$ AND $9W^{1/3}$)

Security personnel at the access point shall also be provided blast protection if at all possible. This protection may be provided by separating the checkpoint from vehicle barricades by a blast zone. The blast zone is measured from the barricades to the nearest traffic control post or the visitor control center. Refer to Table 4-2 below, column (unbar.) for the required blast zone distances. If the required distance cannot be attained, the next column, (Bar), may be used if a blast barricade is placed between the checkpoint facilities and the vehicle barricades.

### 4.15.3 Fragments

The above zones are based upon quantity-distance tables related to blast overpressures. The danger due to fragments and flying debris will extend beyond the distances in Table 4-2. For quantities of TNT of 100 lbs or less, the fragment zone extends 670 feet. For quantities over 100 lbs, the fragment zone extends 1,250 ft. Low angle, high velocity fragments may be intercepted by blast barriers.

### 4.15.4 Blast Barriers

Properly constructed blast barriers are effective against high velocity, low angle fragments. They also provide limited protection against blast overpressures in their immediate vicinity. They do not provide any protection against high angle fragments and are not effective in reducing the blast overpressures in the far field (distances greater than 4 times the height of barrier). For this reason, even when barricades are used, individual buildings may still require protection to protect them and their occupants from the effects of blast overpressure. When blast barriers are used alongside the access points, the overpressures at the checkpoints must be ckecked as per TW 5-1300. due to the reflected overpressures set up by the blast barriers, the blast distances given in the table below may not apply.

TABLE 4-2 BLAST & SAFETY DISTANCES

| AMOUNT OF MATERIAL IN POUNDS OF TNT | SAFETY DISTANCES INHAB. BLDG. | PUB. ROADS | BLAST DISTANCES UNBAR. | BAR. |
|---|---|---|---|---|
| Less than 50 lbs | 150 ft | 90 ft | 60 ft | 30 ft |
| 50-100 lbs | 190 | 115 | 80 | 40 |
| 100-300 | 276 | 160 | 120 | 60 |
| 300-1,000 | 400 | 240 | 180 | 90 |
| 1,000-2,000 | 505 | 305 | 230 | 115 |
| 2,000-4,000 | 635 | 380 | 290 | 145 |
| 4,000-7,000 | 770 | 460 | 340 | 170 |
| 7,000-10,000 | 865 | 520 | 390 | 195 |
| 10,000-15,000 | 990 | 595 | 450 | 225 |
| 15,000-20,000 lbs | 1,090 ft | 655 ft | 490 ft | 245 ft |
| PEAK OVERPRESSURE | 1.2 psi | 2.3 psi | 3.5 psi | 11 psi |
| DISTANCE FACTOR | $40W^{1/3}$ | $24W^{1/3}$ | $18W^{1/3}$ | $9W^{1/3}$ |

ADAPTED FROM DOD 6055.9 STD

W = NET WEIGHT OF HIGH EXPLOSIVE MATERIAL

# 5.0 CONCLUSIONS

This study identified a range of devices that may be combined in many ways to provide protection against the threats identified. The design cases identified for this study are very generalized; thus, they do not provide specific information on such factors as the threat, the terrain, the volume of traffic, and the distances between the public road, the checkpoint, and the main part of the base. This information is necessary to develop a realistic solution and to select the proper static barriers, vehicle barricades, gatehouses, and the number of incoming and outgoing lanes.

The development of these concepts became an exercise in finding different ways to combine various elements of a common vocabulary to provide concepts for each design case. Several of the concepts meet the conditions of more than one design case. The various concepts are frequently based on different assumptions and, thus, any one concept will not be suitable for all situations. Both Concepts BB and BC solve the requirements of Case 4. However, Concept BB assumes that the access point can be placed between the base and the public road. Concept BC assumes that there is not adequate room to place the access point between the base and the perimeter of the base. Concept BC would work if the access point could be located in the heart of the base.

Therefore, this definitive design with a series of generalized concepts has been developed. These generalized concepts employ a common vocabulary of static barriers, vehicle barricades, gatehouses, and traffic control and detection systems.

Ideally, local security planners will be able to utilize one of these concepts by modifying it to conform to the local requirements of their installation. The vocabulary of static barriers, vehicle barricades, gatehouses, blast barriers, and traffic control devices should assist them in adapting these concepts for their use.

## 5.1 SUMMARY OF FINDINGS

- A range of individual components, including gatehouses, static barriers, and vehicle barricades have been the subject of several previous studies. Some of these components meet the criteria given for this study. Some of these components have been or are being tested in the field.
- Gatehouses meeting the required criteria can be built from fairly common building materials. Also, such gatehouses are readily available as prefabricated buildings. The threat identified in this study will require the gatehouses to be designed with various degrees of protection.
- A wide range of static barriers have been identified by other studies. One reference classified these barriers as low, medium, and high band barriers according to their effectiveness. Some of these barriers have been tested, and some of them are suitable for use against the threat defined in this study.
- A limited variety of vehicle barricades are commercially available. There are manufacturers in Europe as well as the U.S. that design, test, and build these barricades. The barricades vary in their design parameters. The response times also vary from over 10 seconds to less than 2 seconds. Most of these barricades constitute a lethal force to occupants in a vehicle traveling above moderate speeds. A few of these barricades will stop the vehicle defined in this study and remain in condition to stop another vehicle. Many of the barricades will stop the design vehicle with some damage to the barricade. All of the barricades will stop the design vehicle if it were first slowed down by some other means.
- The various manufactured barricades may be controlled manually and by a wide variety of devices or systems including radar, detection loops, light beams, and treadle switches.

- TV cameras and card readers may be used with these devices to control the flow of traffic through the access points. Such devices will minimize the exposure of the guards to the threat.
- The vehicle barricades need to be at least 865 feet from major facilities on the military base to prevent severe damage to those facilities in the event of an explosion of 10,000 pounds of TNT at the barricades. The gatehouses should be 390 feet from the barricades to minimize the danger to the guards. Greater distances make it difficult for the guards to control the barricades and the ground between it and the gatehouses. Lesser distances place the guards in greater danger in the event of an explosion at the barricades. At 390 feet, the gatehouse should be designed for a blast overpressure of 3.5 psi.
- The approach distance to the vehicle barricades is determined by the operating time of the barricades and the reaction time of the guards or some controlling device.
- The vehicle approach to the vehicle barricades will control the approach speed of the design vehicle. Sharp turns and static barriers are effective in controlling the approach of all vehicles.

## 5.2 SUMMARY OF RECOMMENDATIONS

- A series of generalized concepts have been developed. These generalized concepts employ a vocabulary of static barriers, vehicle barricades, gatehouses, and traffic control and detection devices. Local security planners should be allowed to select a concept to meet their situation and then modify that concept using the vocabulary of design elements to make that concept meet their local requirements.

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TECHNICAL MEMORANDUM 505-4

Texas Transportation Institute
Texas A&M Research Foundation

# DRAGNET VEHICLE ARRESTING SYSTEM

A Tentative Progress Memorandum on Contract No. CPR-11-5851

U. S. Department of Transportation
Federal Highway Administration
Bureau of Public Roads

by

T. J. Hirsch
Research Engineer and Principal Investigator

Gordon G. Hayes
Engineering Research Associate

and

Don L. Ivey
Associate Research Engineer

Crash tests and evaluations were conducted under the Office of Research and Development, Structures and Applied Mechanics Division's, Research Program on Structural Systems in Support of Highway Safety (4S Program). The opinions, findings, and conclusions expressed in this report are those of the authors and not necessarily those of the Bureau of Public Roads.

Note: For the reader who is interested in gaining a general idea of the value of this particular arresting system and not in the details necessary to document the technical aspects of this study, the authors recommend reading pages 2 and 5 and scanning the photographs in this report.

February 28, 1969

## INTRODUCTION

Six crash tests of a "dragnet" vehicle arresting system were conducted by the Texas Transportation Institute under a contract with the Bureau of Public Roads as part of their program on Structural Systems in Support of Highway Safety. This "dragnet" system uses Metal Bender energy absorbing devices developed by Van Zelm Associates, Inc., of 1475 Elmwood Avenue, Providence, Rhode Island. Descriptions include photographs of the vehicle and arresting system before, during and after each individual test.

## DESCRIPTION OF ARRESTING SYSTEM

This system consists of a net made of steel cables attached at each end to Metal Bender energy absorbing devices as shown in Figure A1. The Metal Benders, which are supported on rigid steel posts, are steel boxes containing a series of rollers around which the metal tape is bent back and forth as it is pulled through the case. Each end of the net is attached to one end of the metal tape extending from a Metal Bender. The Metal Benders are designed so that a specified force will be necessary to pull the metal tape through the case. This force is relatively independent of velocity and environmental conditions and depends on the size of the tape used. By varying tape size a number of different tape forces are available.

Supplementary construction and installation data on this system were provided by Van Zelm Associates, Inc.* and are presented in Appendix A. Photographs of the arresting system used in these tests are shown in Figures 2 and 3.

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* Jackson, M. and Montanaro, L., "Arresting System for Snagging a Vehicle Leaving the Roadway Near Fixed Highway Obstacles," Van Zelm Associates, Inc., A Division of Entwistle Mfg. Corp., May 8, 1967.

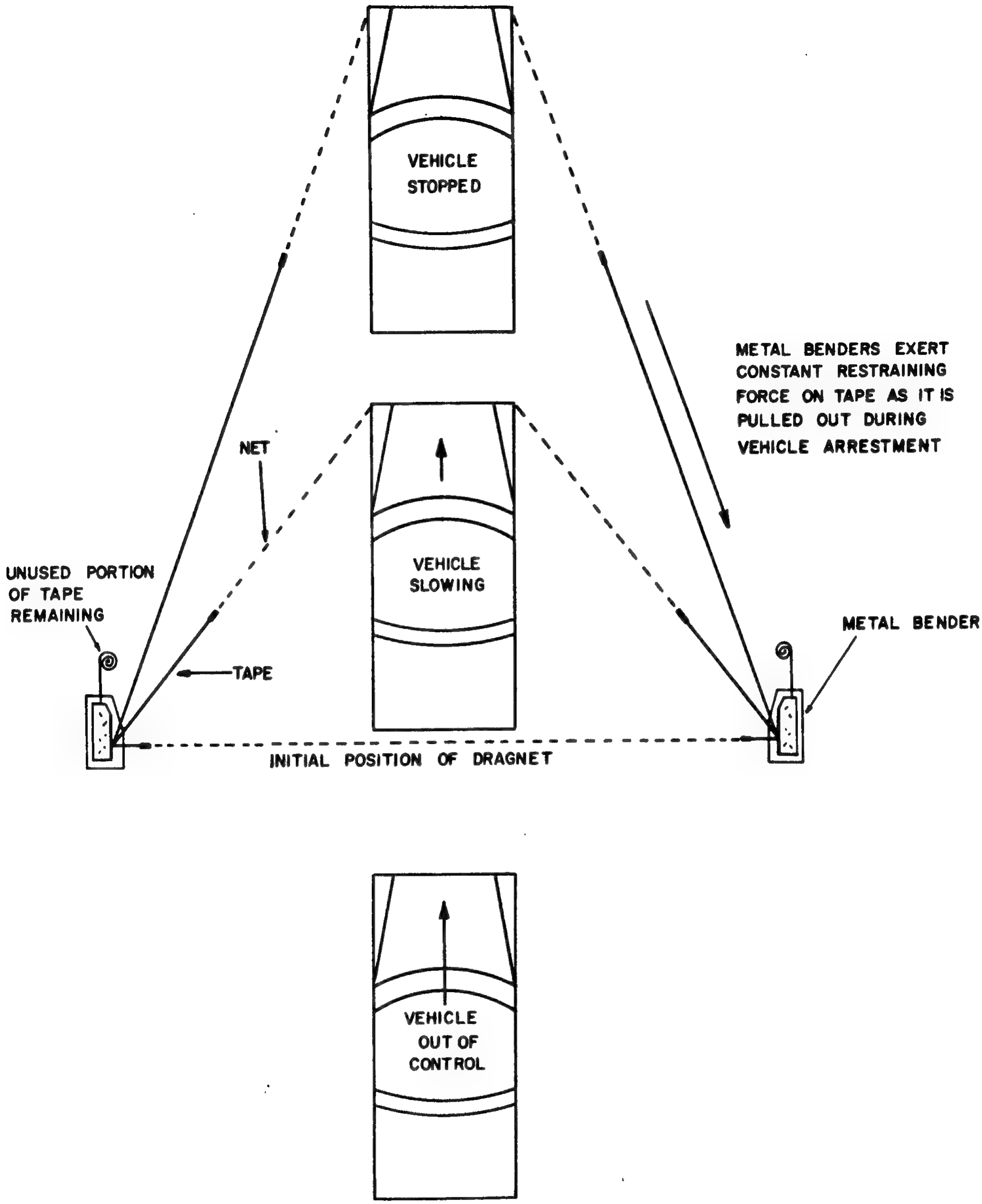


FIGURE 1, IDEALIZED FUNCTION OF DRAGNET ARRESTING SYSTEM

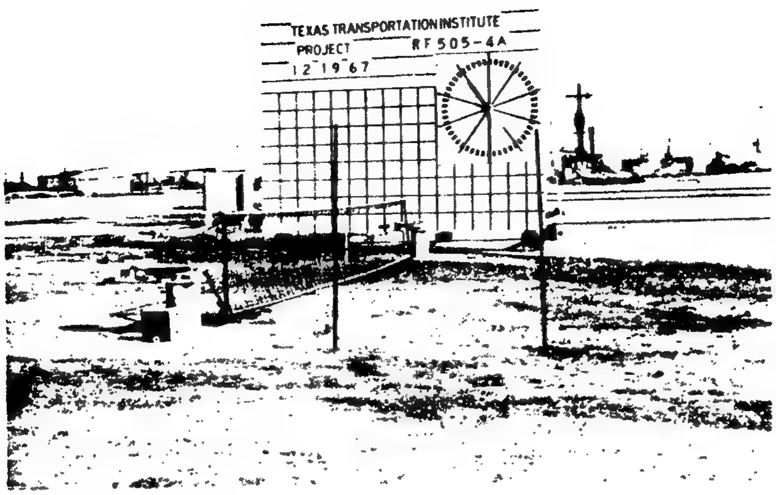


Figure 2, Dragnet Arresting System
Before Test 505-4A.

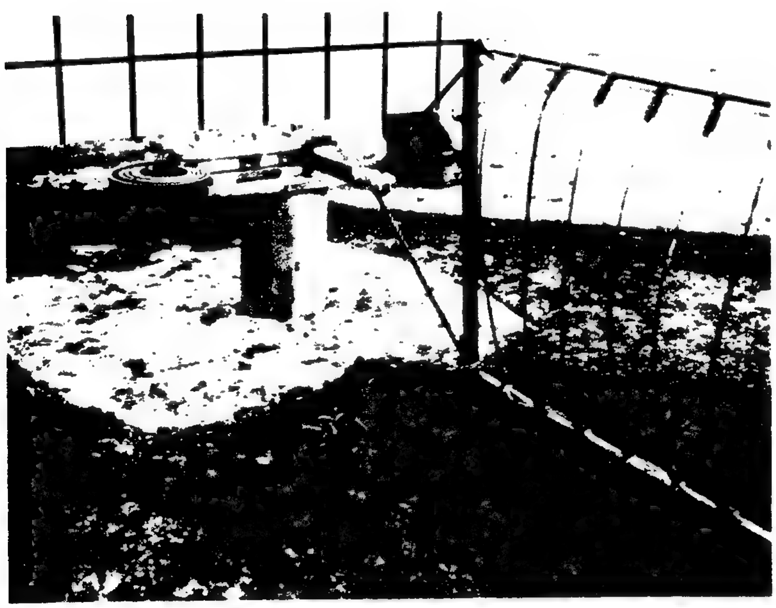

Figure 3, Metal Bender with 25,000 lb. Tape
Attached to Net.

## CONCLUSIONS

The Van Zelm dragnet vehicle arresting system performed basically as designed in all tests. The performance of the system was very good in four of the six tests. In Test 4D the dragnet was engaged too low on the front of the vehicle, which resulted in the vehicle's rear end vaulting the net after most of the longitudinal deceleration had occurred. In Test 4F the performance of the dragnet system was ideal until one of the tapes ran out. Had this tape been long enough to continue applying load until the vehicle was completely stopped, the performance probably would have been excellent. Deceleration levels were reduced to a small fraction of those which would be expected in rigid barrier impacts. Increasing design tape load results in shortening the stopping distance, increasing the deceleration level and increasing vehicle damage. For any given application of the dragnet system, the longer the allowable stopping distance, the more desirable are the deceleration characteristics of the system because a smaller tape load can be used.

The height of the net was shown to be an important factor in the performance of the system. The net should be positioned so that it completely entraps the front of the entering vehicle. If it is too low, a less desirable performance may be expected, as was found in Test 4D. Good performance was found when the lower main cable of the net was positioned four inches above the ground.

No permanent damage was sustained by the dragnet system during any of these tests. All major components were reusable except for the expendable metal tapes. The system can be applied to a variety of situations by varying the Metal Bender tape tension, the tape length, and the geometry

of the installation. A variety of Metal Bender tape tensions are available, some of which are given in Appendix A.

This series of tests has shown that reasonably accurate predictions of vehicle stopping distance and deceleration levels can be obtained using the equations developed in Appendix B.

## RECOMMENDATIONS

The "dragnet" vehicle arresting system is an effective, practical, and economical system for safely stopping vehicles which are out of control at certain highway sites. Some obvious sites for its employment are:

1. Protecting highway medians at bridge overpasses,
2. As a barrier at "dead ends" of highways or roads,
3. As a "dead-end" barrier at ferry landings or as a barrier to close off entrance and exit ramps of freeways,
4. As a barrier to protect certain rigid obstacles in highway rights-of-way.

It is recommended that the height of the arresting net be increased to approximately 4 ft. The net used in the tests was 3 ft. high, and in several tests (notably Test 4D) failed to completely entrap the vehicle's front end. It is desirable that the upper net cable clear the top of the car hood in order to more securely entrap the vehicle.

The lowest Metal Bender tension force which is compatible with the available stopping distance should be selected. In general, Metal Bender tension forces of 12,500 lb. or less are recommended. The behavior of these "dragnet" systems can be predicted very well with the mathematical analysis presented in Appendix B.

It is the opinion of the authors that with Metal Bender tension forces of 8,000 lbs. or less, acceptable stopping characteristics would be achieved with the Metal Benders mounted flush with the ground, thus removing the hazard of the protruding anchor post or pier. Metal Benders of 4,000 lbs. or less can be mounted on single 6 to 8 inch diameter timber posts embedded 3 ft. or more in the ground unless the ground is extremely soft. The top of the timber post should not extend over 20 inches above the ground. These single timber posts would normally not be a significant hazard if struck by a vehicle.

## TEST PROGRAM

Six vehicle crash tests of the "dragnet" arresting system were conducted during the period of December 19, 1967 to November 21, 1968. A summary of this testing program is given by Table 1. Both compact and full-size vehicles were directed into the system. Tests 4A through 4D employed Metal Benders with 25,000 pound tape loads. These tape loads were reduced to 12,500 pounds for Tests 4E and 4F.

Each test was recorded using high-speed motion picture cameras. This film was analyzed to give detailed time-displacement data. Lower speed motion picture cameras were placed at selected points to provide a qualitative record of the test in progress. Still photographs of the vehicle before and after each test and photographs of various details of the arresting system were obtained.

Accelerometer transducers were attached to the frames of the vehicles to determine deceleration levels during each test. Deceleration traces are presented in Appendix C. Maximum decelerations under specified filtering techniques were determined from these accelerometer traces, while average decelerations were calculated on the basis of initial speed and stopping distance.

An Alderson articulated anthropometric dummy weighing 161 pounds was used to simulate a human driver in each test. A seat belt securing the dummy was equipped with strain guages which permitted the measurement of seat belt force. Variation in this seat belt force during the progress of each test is presented in Appendix C.

TABLE 1

Summary of Test Program

On Van Zelm "Dragnet" Arresting System

| Test No. | 4A | 4B | 4C | 4D | 4E | 4F |
|---|---|---|---|---|---|---|
| Angle of Attack | Head-On | Head-On | $30^{\circ}$ | $30^{\circ}$ | Head-On | $30^{\circ}$ |
| Tape Arresting Load (Kips) | 25.0 | 25.0 | 25.0 | 25.0 | 12.5 | 12.5 |
| Vehicle Weight (lbs.) | 1460 | 4300 | 1620 | 4520 | 3760 | 3880 |
| Vehicle Speed (mph) (fps) | 42<br>61.8 | 60<br>87.4 | 48<br>69.7 | 54<br>78.7 | 56<br>82.6 | 62<br>91.9 |
| Vehicle Kinetic Energy (Kip-ft) | 87.1 | 513. | 123. | 437. | 401. | 512. |

TEST 4A

A Renault Dauphine weighing 1460 pounds was directed head-on into the dragnet at a speed of 42 mph. The tape force for each Metal Bender was 25,000 pounds. All components of the system performed as designed and the vehicle was stopped after penetrating 10.2 feet. Stopping distance is defined as the distance the center of gravity of the vehicle travels after the car contacts the net. The Metal Bender strap pullout accounted for 63% of the vehicle's initial kinetic energy of 87.1 kip-ft. The remaining energy was expended in stretching the net, crushing the vehicle (see Figure 5), and increasing the vehicle's potential energy due to raising the center of gravity. The amount expended in increasing gravitational potential energy was only about one kip-ft.

The damage to the front of the vehicle was severe. The maximum longitudinal deceleration, shown in Figure C1, was 16 g's. The average deceleration was 5.8 g's over .25 seconds.

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Figure 4, Sequential Photographs of Test 505-4A

Figure 5, Vehicle and Dragnet after Test 505-4A.

TEST 4B

A 4300 pound Mercury sedan traveling 60 mph was directed head-on into the arresting system. The dragnet, which was equipped with 25,000 pound tape tension Metal Benders performed as designed. The vehicle was brought to a stop in 19.4 feet and tape pullout expended 58% of the vehicle's energy. The front of the vehicle was pulled down to the ground which caused some frictional energy losses. The change in potential energy due to the elevation of the center of gravity was estimated to be about 17 kip-ft, or 3.3% of the initial energy.

The damage to the front of the vehicle, shown in Figure 9, includes a downward bending of the front of the vehicle's frame. This was due to the net applying pressure to the lower portion of the vehicle's front end. The maximum significant deceleration, shown by Figure C3, was 16 g's, and the average deceleration was 6.1 g's.

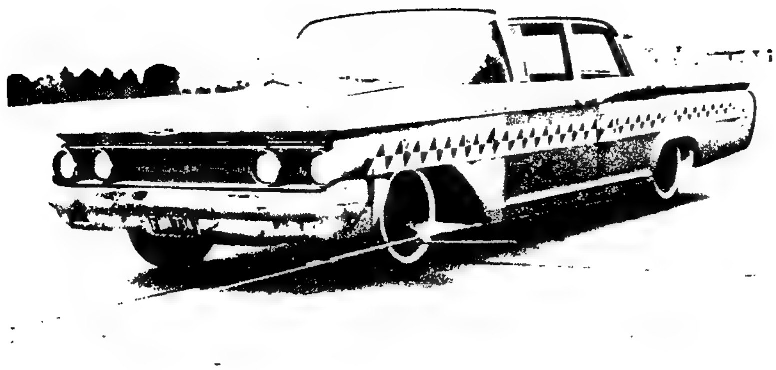

Figure 6 , Vehicle Before Test 505-4B.

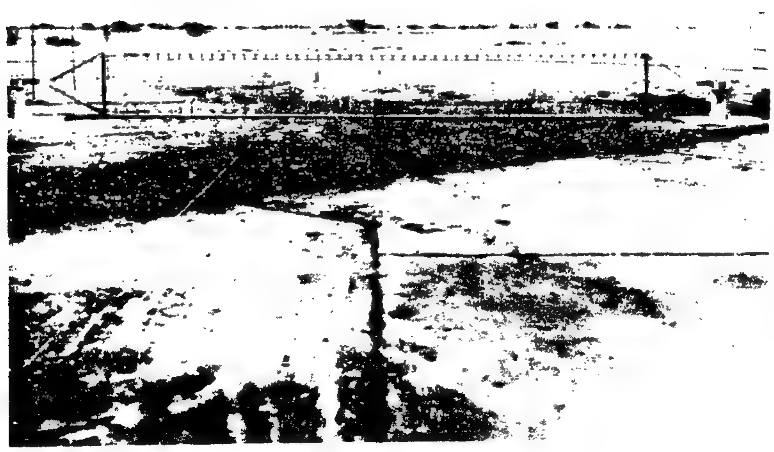

Figure 7 , Arresting System Before Test 505-4B.
(Looking Along Path of Vehicle)

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Figure 8, Sequential Photographs of Test 505-4B.

Figure 9, Vehicle After Test 505-4B.

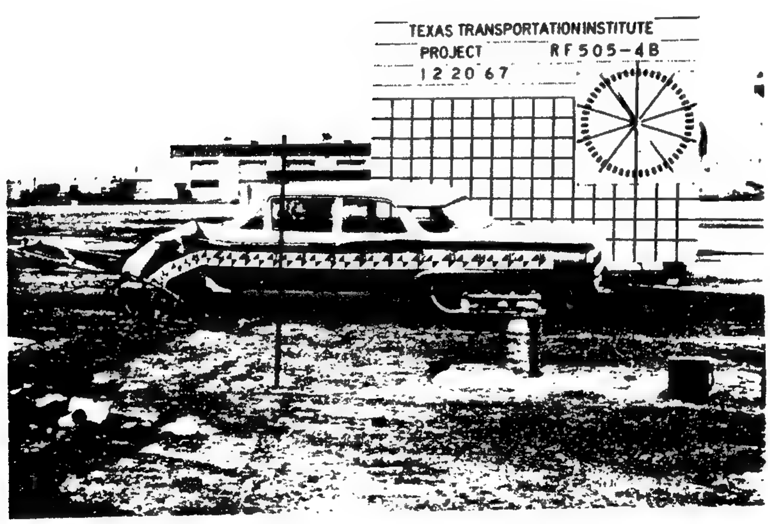



Figure 10, Vehicle and Left Metal Bender
After Test 505-4B.

TEST 4C

A 1620 pound Volkswagen traveling at 48 mph entered the arresting system at an angle of 30° with a perpendicular to the net. All subsequent angle tests will be defined on this basis. The vehicle was stopped in 13.8 feet, and pulled a total of 3.4 feet of tape out of the 25,000 pound Metal Benders. This tape pullout consumed 70% of the vehicle's kinetic energy. The estimated energy necessary to impart a horizontal rotation, or spin, to the vehicle and to elevate its center of gravity was about 3 kip-ft. These energy levels are defined at the time during the test when the tapes stop pulling out of the benders. The average deceleration level was 5.5 g's while the maximum deceleration, shown by Figure C5 is about 13 g's. The vehicle damage shown in Figure 12 was moderate.

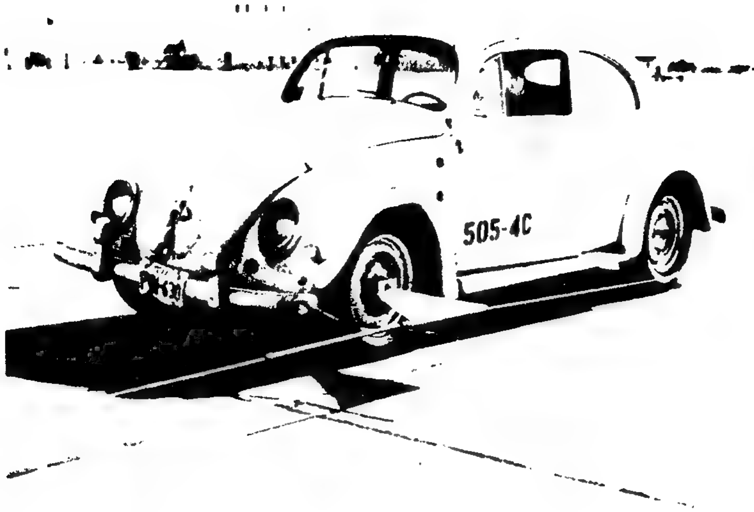



Figure 11, Vehicle Before Test 505-4C

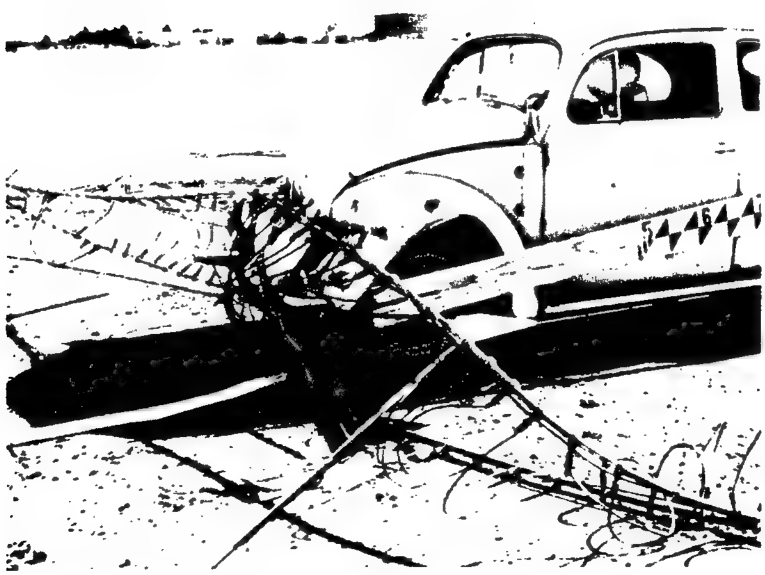


Figure 12, Vehicle After Test 505-4C

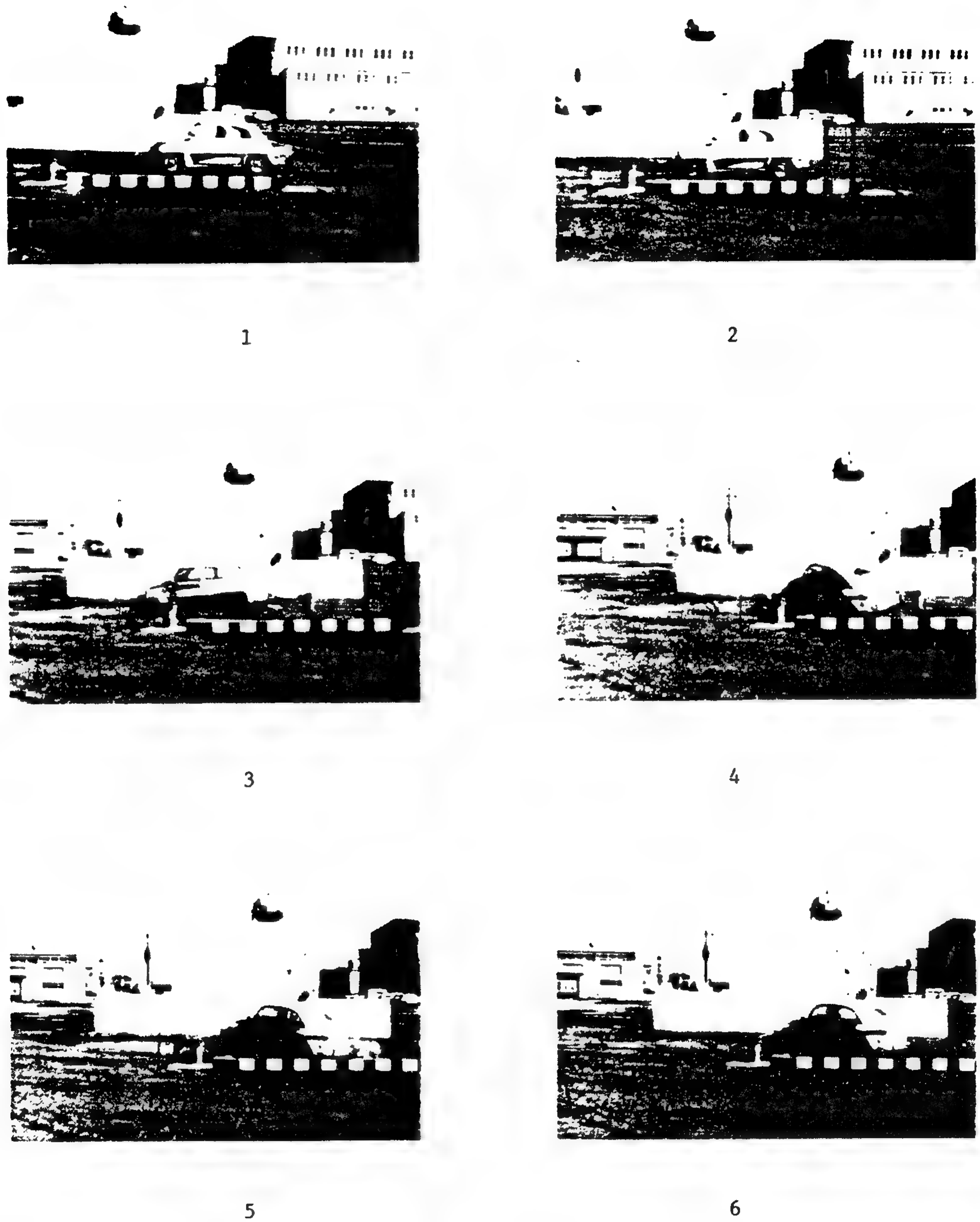



Figure 13, Sequential Photographs of Test 505-4C.

TEST 4D

In Test 4D a 4520 pound Oldsmobile sedan, traveling 54 mph, impacted the net on an initial trajectory of 30°. The high-speed films show a maximum travel of 23.5 feet after impact. The 25,000 pound Metal Benders allowed 8.6 feet of metal tape to be pulled through, accounting for 50% of the initial kinetic energy. When the maximum tape pullout had occurred, the vehicle was estimated to have 36 kip-ft of rotational energy and 11 kip-ft of gravitational potential energy. The net entrapped only the lower portion of the front of the vehicle. As the front pulled down below the vehicle center of gravity, the unbalanced inertia force resulted in the vehicle's rotation about the restrained point (see Figure 17). The vehicle was completely off the ground and the rear end went over and outside of the restraining net after the tapes had stopped pulling out. When the vehicle fell back to the ground, it came very close to rolling. The average and maximum significant longitudinal decelerations were 4.1 and 8 g's respectively. Figure C7 shows the accelerometer trace used to determine this maximum deceleration.

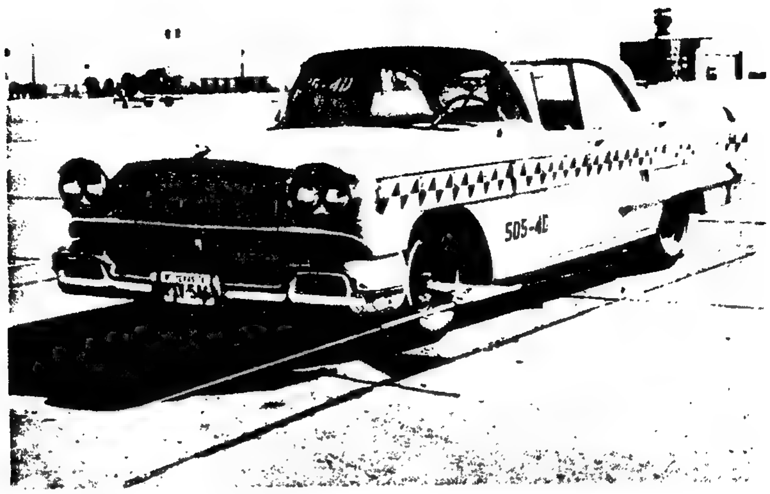



Figure 14, Vehicle Before Test 505-4D.

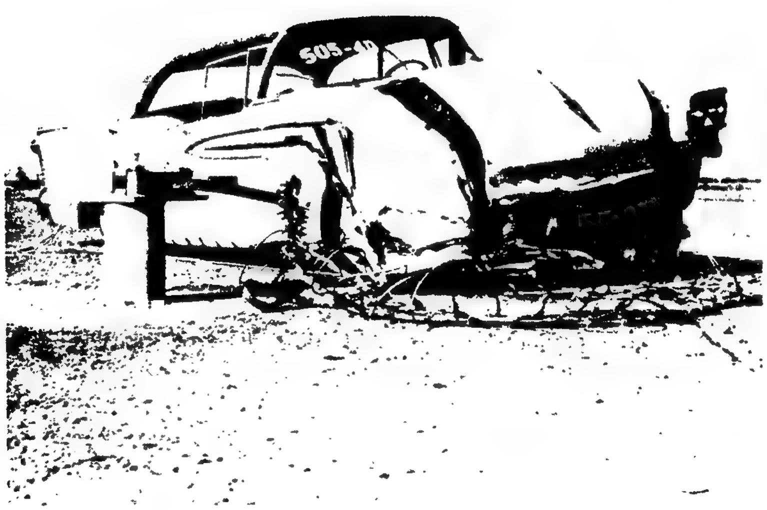


Figure 15, Vehicle and Right Metal Bender
After Test 505-4D.

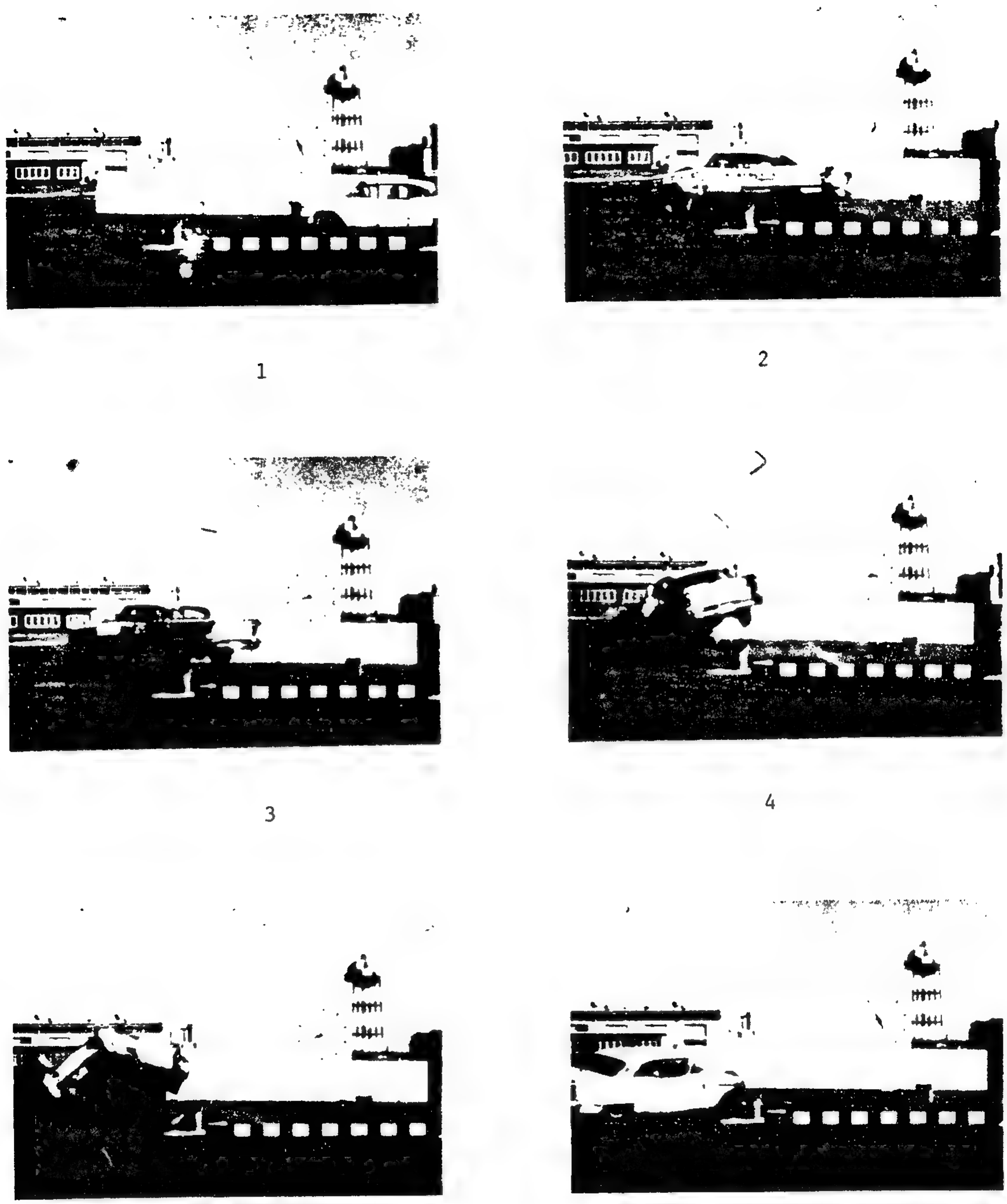



Figure 16, Sequential Photographs of Test 505-4D.

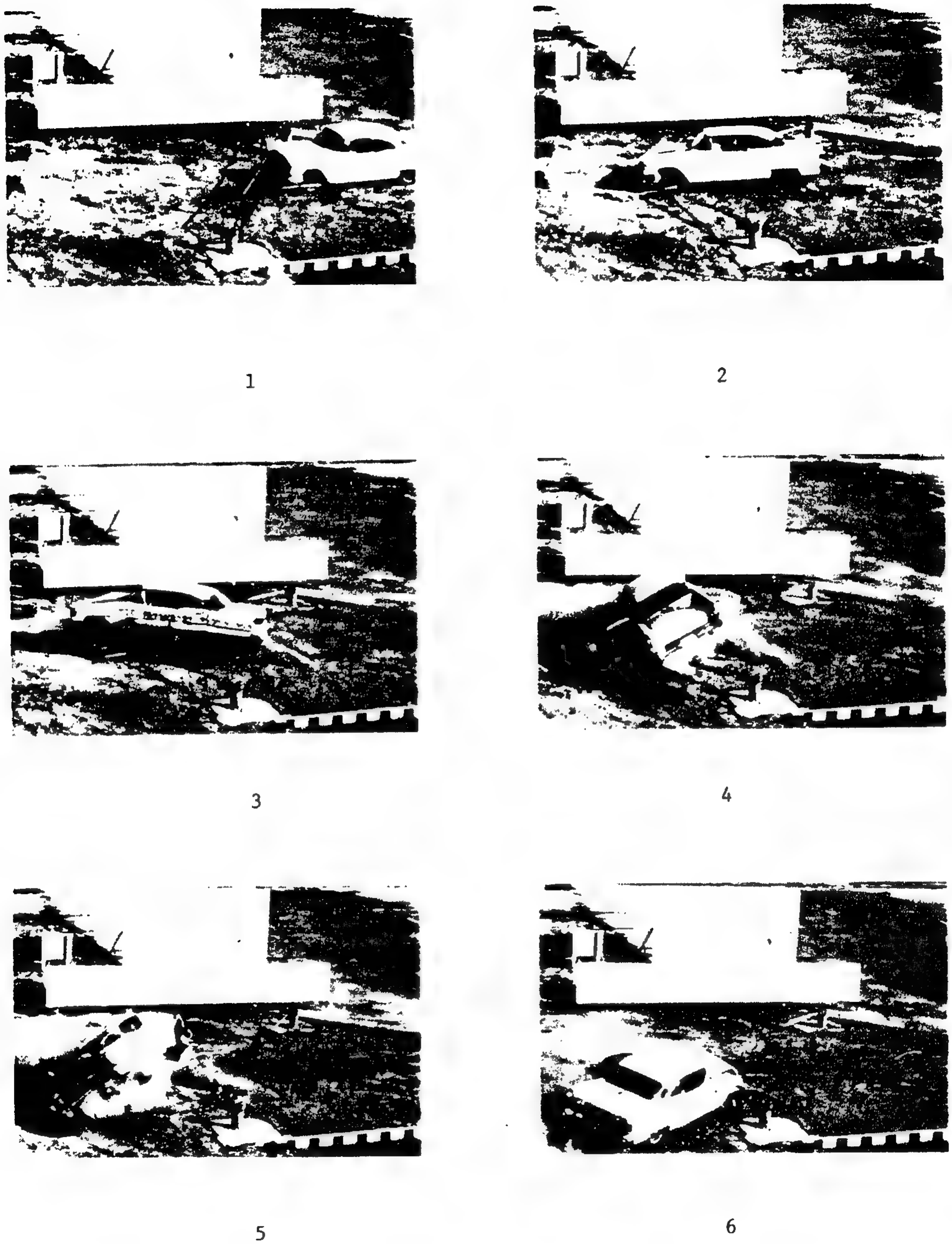



Figure 17, Sequential Photographs of Test 505-4D Showing Behavior of Net During Arrestment.

TEST 4E

This test was similar to Test 4B in that a heavy car, a 3760 lb. Dodge sedan, was directed head-on into the dragnet at a velocity of 56 mph. However, in this and the following test the Metal Bender tape load was decreased to 12,500 lbs. and the net was raised about 4 inches off the ground to better entrap the front of the vehicles.

The vehicle was stopped in 26.3 feet and pulled out a total of 30.7 feet of tape, which is equivalent to 384 kip-ft, or 96% of the vehicle's kinetic energy. The vehicle had no significant rotational energy at maximum penetration, but had gained about 7 kip-ft of gravitational potential energy.

The vehicle damage was minor,as would be expected since the maximum deceleration was only 7.0 g's, and the average deceleration was 4.0 g's.

Figure 18, Vehicle Before Test 505-4E.

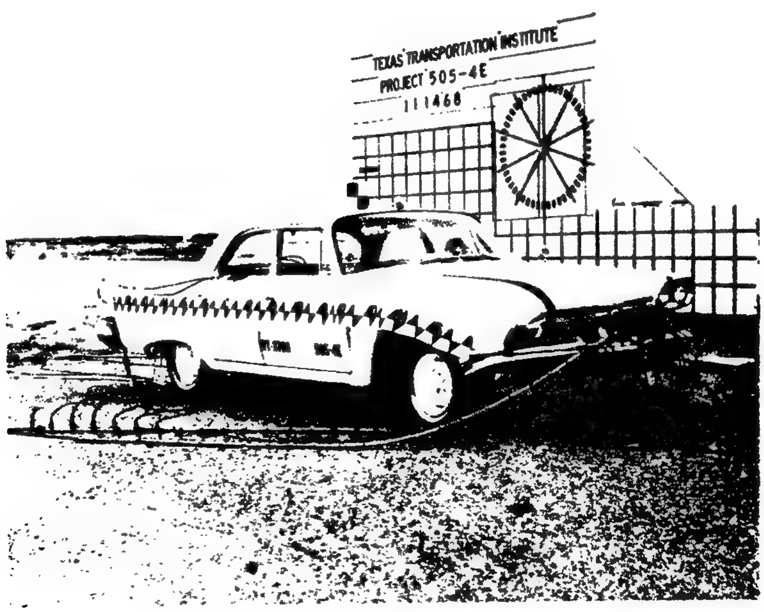



Figure 19, Vehicle After Test 505-4E.

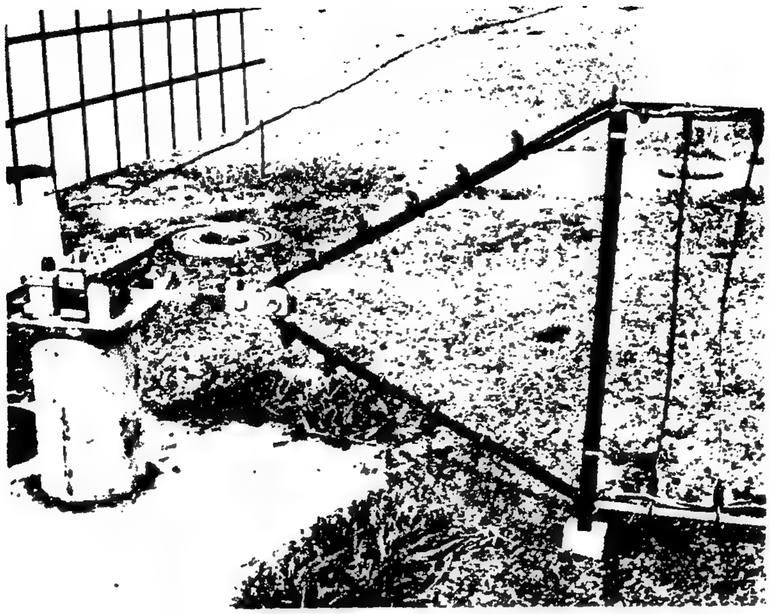
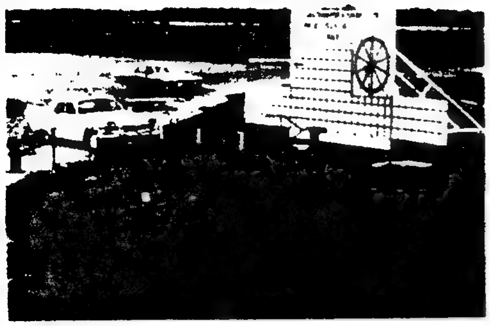
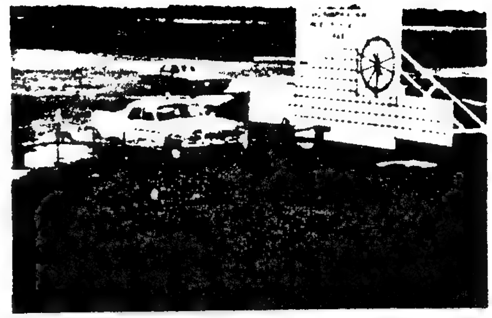


Figure 20, 12,500 Pound Metal Bender Before Test 505-4E.
(Note smaller metal tape)

Figure 21, Dummy Used In All Tests
To Simulate Human Driver.



1



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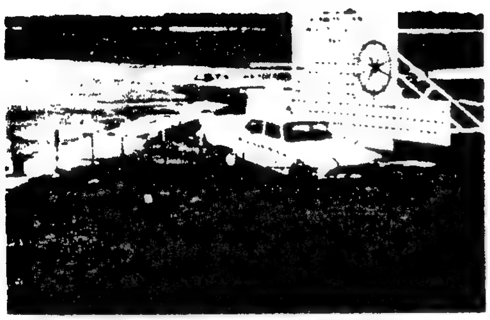

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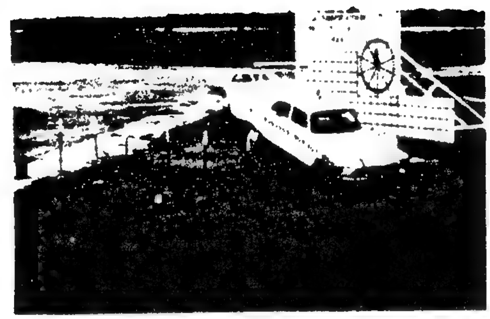

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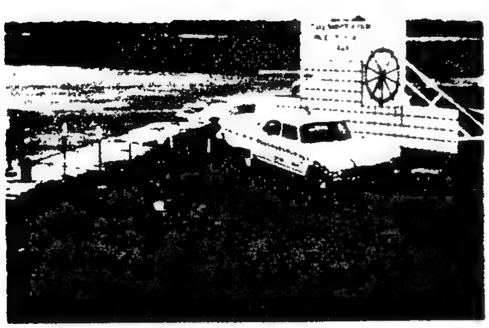

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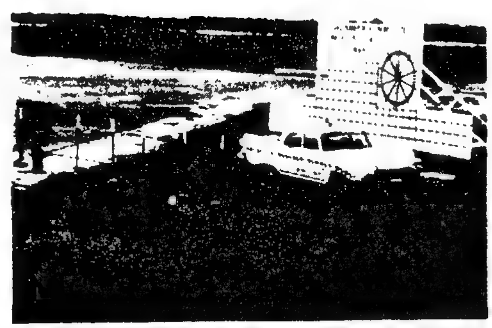

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Figure 22, Sequential Photographs of Test 505-4E.

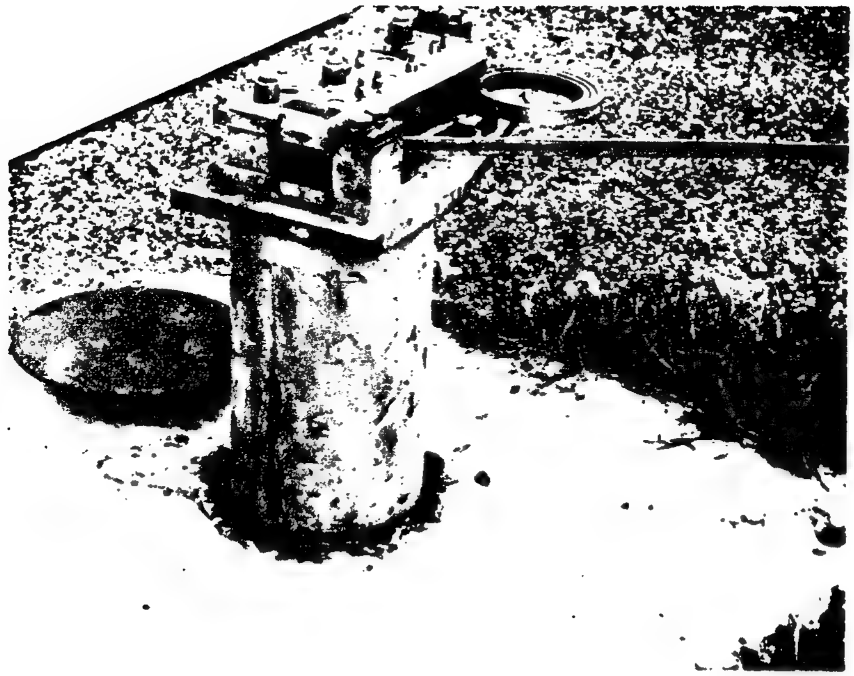

Figure 23, Metal Bender After Test 505-4E.
(Approximately the same amount
of tape remained on each bender)

TEST 4F

As the final test in this series a 3880 pound Ford sedan traveling 62 mph collided with the dragnet at an impact angle of 30°. As in the previous test, 12,500 pound Metal Bender tapes were used.

The tape on the right side was expended and pulled free of the Metal Bender before the vehicle had been brought to a stop. The system performed as designed up to the point of tape pullout. The net, which was still attached to one Metal Bender, caused the car to spin through an angle of about 120 degrees after pulling out the right tape before coming to rest.

The total tape pullout when the right tape pulled free was 32.9 feet, which accounts for 89% of the kinetic energy lost up to that point. The high-speed films indicate that the vehicle had lost about 91% of its initial energy at this point and that the speed was down to about 17 mph.

The total tape pullout of 38.5 feet at full stop accounts for 94% of the vehicle's initial energy. Comparisons of actual and theoretical values are made up to the point of tape expenditure.

The deceleration levels of 5.0 g's (maximum) and 2.4 g's (average) are tolerable to restrained humans.*

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* Damon, Albert; Stoudt, Howard W.; and McFarland, Ross A., The Human Body in Equipment Design, Harvard University Press, Cambridge, Massachusetts, 1966.

Figure 24, Vehicle Before Test 505-4F.

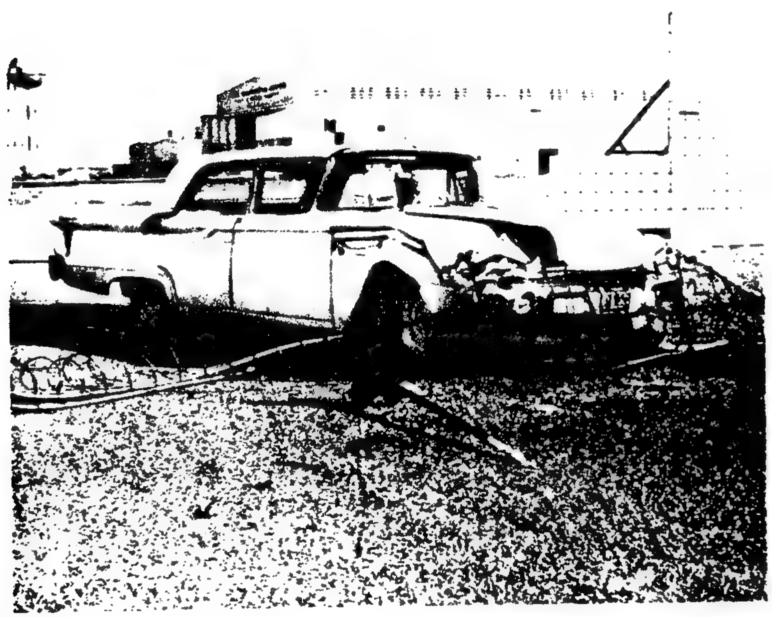

Figure 25, Vehicle After Test 505-4F.

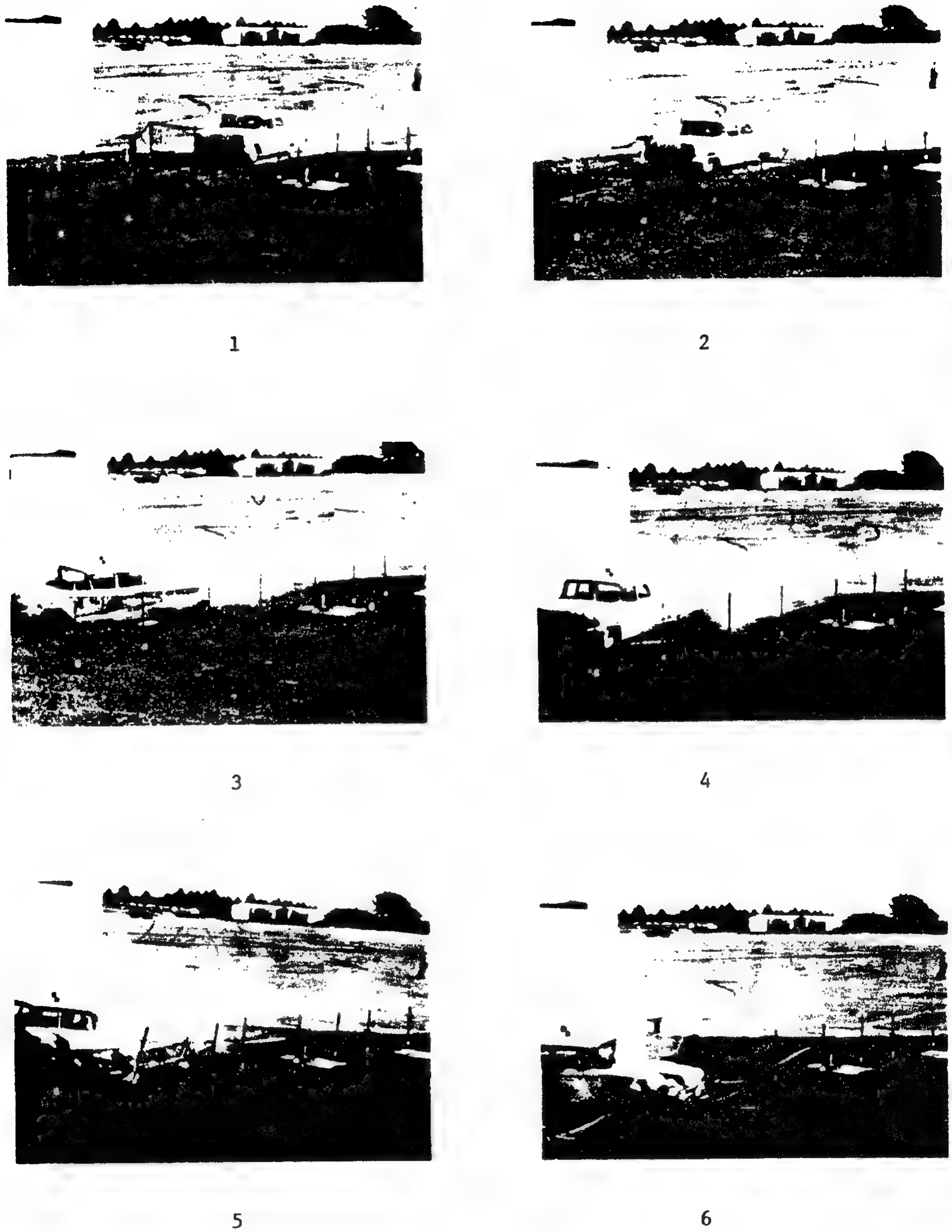


Figure 26, Sequential Photographs of Test 505-4F.

## DISCUSSION

The complete test series which was conducted on the Van Zelm dragnet is summarized by Table 2. The vehicles used ranged in weight from 1460 lbs to 4520 lbs. All test vehicles impacted the dragnet at its center. Tests 4A, 4B, and 4E were head-on tests, while Tests 4C, 4D, and 4F were 30° angle tests. This means that the initial trajectory of the vehicle made an angle of 30° with a perpendicular to the original position of the dragnet. Tapes producing a 25 kip pull were used in Tests 4A through 4D, while in Tests 4E and 4F this tape force was reduced to 12.5 kips.

The energy absorbed by the Metal Benders ranged from 50% to 70% of the vehicle's initial kinetic energy for the first four tests which used the 25 kip tape loads. In Tests 4E and 4F the percent of energy absorbed by the Metal Benders ranged from 89% to 96%. Inspection of Table 3 will show several reasons for this difference. At the end of Metal Bender tape pullout, which corresponds approximately to zero longitudinal velocity, significant amounts of energy may remain in the form of gravitational potential energy and rotational kinetic energy. In most impacts there is some gravitational potential energy gain due to the tendency of the net to pull the vehicle down in front and for the rear end to rise. This results in an increase in the elevation of the vehicle's center of gravity. The total vehicle weight times this increase in elevation, $E_P$, is designated the gravitational potential energy at the end of tape travel. In the case of angle tests, there may be present a significant amount of horizontal rotational energy, $E_{RV}$, which is equal to one-half the product of the vehicle mass moment of inertia (about the vertical axis through the vehicle's center of gravity) times the square of the vehicle's angular

| TEST NO. | 4A | 4B | 4C | 4D | 4E | 4F |
|---|---|---|---|---|---|---|
| Angle of Impact | Head-On | Head-On | 30° | 30° | Head-On | 30° |
| Vehicle Weight (lbs) | 1460 | 4300 | 1620 | 4520 | 3760 | 3880 |
| Vehicle Velocity (mph) | 42 | 60 | 48 | 54 | 56 | 62 |
| Metal Bender Tape Load (kip) | 25.0 | 25.0 | 25.0 | 25.0 | 12.5 | 12.5 |
| Vehicle Deformation (ft) | 1.8 | 1.0 | 0.9 | 1.5 | 0.3 | 0.5 |
| Vehicle Stopping Distance (ft) | 10.2 | 19.4 | 13.8 | 23.5 | 26.3 | 29.5* |
| Total Metal Bender Tape Pullout (ft) | 2.2 | 11.8 | 3.4 | 8.6 | 30.7 | 32.9* |
| Energy Absorbed by Metal Bender (kip-ft) | 54.8 (63%) | 296 (58%) | 86 (70%) | 214 (50%) | 384 (96%) | 411 * (89%) |
| Max. Significant Deceleration (g's) (Electromechanical curves) | 16 | 16 | 13 | 8 | 7.0 | 5.0 |
| Avg. Deceleration (g's) (Film - $V^2/2gX_{max}$) | 5.8 | 6.1 | 5.5 | 4.1 | 4.0 | 2.4* |
| **REMARKS** | | | | | | |
| Dragnet Performance | | | | | | |
| Vehicle Damage | | | | | | |
| Dragnet Damage | | | | | | |
| Deceleration Level | | | | | | |

* Up to point tape expended.

TABLE 2. SUMMARY OF TEST RESULTS

TABLE 3

| TEST NO. | 4A | 4B | 4C | 4D | 4E | 4F* |
|---|---|---|---|---|---|---|
| $E_{KI}$ | 87 | 513 | 123 | 437 | 401 | 512 |
| $E_{MB}$ | 55 | 296 | 86 | 214 | 384 | 481 |
| $E_P$ | 1 | 17 | 2 | 11 | 7 | 0 |
| $E_{RV}$ | 0 | 0 | 1 | 34 | 0 | 0 |
| $E_{RL}$ | 0 | 0 | 0 | 2 | 0 | 0 |
| $E_M$ | 31 | 200 | 34 | 176 | 10 | 31 |

$E_{KI}$ = Initial vehicle kinetic energy

$E_{MB}$ = Energy expended in Metal Bender tape pullout

$E_P$ = Gravitational potential energy at end of tape travel

$E_{RV}$ = Horizontal rotational energy (around vertical axis) at end of tape travel

$E_{RL}$ = Transverse rotational energy (around longitudinal axis) at end of tape travel

$E_M$ = Miscellaneous energy expenditure (cable stretch, vehicle deformation, contact with ground, etc.)

$$E_M = E_{KI} - (E_{MB} + E_P + E_{RV} + E_{RL})$$

* Note the fact that these energy levels are up to the point of tape pullout only.

velocity about this axis. Also present may be transverse rotational energy, $E_{RL}$, which is defined in the same way as the horizontal rotational energy except that the mass moment of inertia and angular velocity is about the longitudinal vehicle axis. Other energy expenditures, $E_M$, may be accounted for by the axial strain energy which goes into the cable and tapes, the vehicle deformation, and frictional losses such as contact of rigid portions of the vehicle with the ground. This last energy expenditure was prevalent in Test 4B. It can be concluded, at least within the range of tape forces tested, that the lower the tape force the greater the percentage of energy dissipated in the Metal Benders. If the extreme example of a tape with infinite load capacity is considered,almost all of the kinetic energy of the vehicle would be expended in vehicle deformation, rolling, etc.

A convenient way of indicating the relative desirability of dragnet arrestments is to compare the deceleration levels determined by these tests with the decelerations that would be encountered during a collision with a rigid barrier. The Attenuation Index is defined as the ratio of decelerations during an attenuated arrestment (for example by dragnet) with those estimated decelerations during a rigid barrier impact.* Both maximum and average Attenuation Indices ($AI_{max}$ and $AI_{avg}$), which compare maximum and average deceleration levels, are presented in Table 4.

Tests 4E and 4F, using 12,500 pound Metal Benders, have smaller Attenuation Indices than the first four tests. This is the obvious result of cutting the stopping force in half. This reduction in stopping force significantly reduces the vehicle damage. The relatively large

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* Emori, Richard I., "Analytical Approach to Automobile Collisions," SAE Paper 680016, Engineering Congress, Detroit, January 8, 1968.

TABLE 4. COMPARISON OF VAN ZELM "DRAGNET" PERFORMANCE

WITH RIGID BARRIER IMPACT

| Test No. | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| Metal Bender Tape Load (Kip) | 25.0 | 25.0 | 25.0 | 25.0 | 12.5 | 12.5 |
| Vehicle Weight (lb.) | 1460 | 4300 | 1620 | 4520 | 3760 | 3880 |
| Vehicle Velocity (mph) | 42 | 60 | 48 | 54 | 56 | 62 |
| *Maximum Deceleration ($G_{max}$) | | | | | | |
| Dragnet | 16 | 16 | 13 | 8 | 7.0 | 5.0 |
| Rigid Barrier | 37.8 | 54.0 | 43.2 | 48.6 | 50.4 | 55.8 |
| **Average Deceleration ($G_{avg}$) | | | | | | |
| Dragnet | 5.8 | 6.1 | 5.5 | 4.1 | 4.0 | 2.4 |
| Rigid Barrier | 24.1 | 34.4 | 27.6 | 31.0 | 32.1 | 35.6 |
| Attenuation Index | | | | | | |
| $AI_{max} = \frac{G_{max}\text{ Dragnet}}{G_{max}\text{ Rigid}}$ | 0.42 | 0.30 | 0.30 | 0.17 | 0.14 | 0.09 |
| $AI_{avg} = \frac{G_{avg}\text{ Dragnet}}{G_{avg}\text{ Rigid}}$ | 0.24 | 0.18 | 0.20 | 0.13 | 0.12 | 0.07 |

*$G_{max}$ Dragnet is from frame accelerometer data.

$G_{max}$ Rigid = 0.9 (vehicle velocity in mph)***

**$G_{avg}$ Dragnet = $\frac{V^2}{2gX_{max}}$ from film data.

$G_{avg}$ Rigid = 0.574 (Vehicle velocity in mph)***

***Emori, Richard I., "Analytical Approach to Automobile Collisions," SAE Paper 680016, Engineering Congress, Detroit, January 8, 1968.

energy differences between tape energy and initial kinetic energy in Tests 4A through 4D are the result of large energy expenditures on vehicle deformation.

In Appendix B is a theoretical treatment which algebraically relates vehicle weight, velocity, tape force and stopping distance. The error induced by considering the vehicle to have no finite width is approximately compensated for by the fact that after impact the "spreaders" at the ends of the net buckle, increasing the effective length of the net. Due to the fact that the main net cables loop over and under the front of the vehicles, and that the vehicles are deformed differently, some inaccuracy is expected, especially in arrestments with short stopping distances. It is also assumed in the calculations that the vehicle continues along its original path during arrestment, which is only a rough approximation in angled or non-centric hits.

Figure 27 is a plot of dragnet force on the vehicles against distance traveled after contact. The data used for this plot is taken from the theoretical calculations in Appendix B. A comparison of the calculated energy expenditures is shown in Table 5. The theoretical Metal Bender energy expenditures are obtained using the equations presented in Appendix B. As expected, the theory shows the greatest percent error for Test 4A, which had the shortest stopping distance and greatest relative deformation.

From the theoretical treatment a plot of total Metal Bender tape pullout against $X_{max}$, the theoretical stopping distance, was made for head-on 30° angled impacts. Neglecting other energy dissipation modes, the initial vehicle kinetic energy divided by the Metal Bender tape

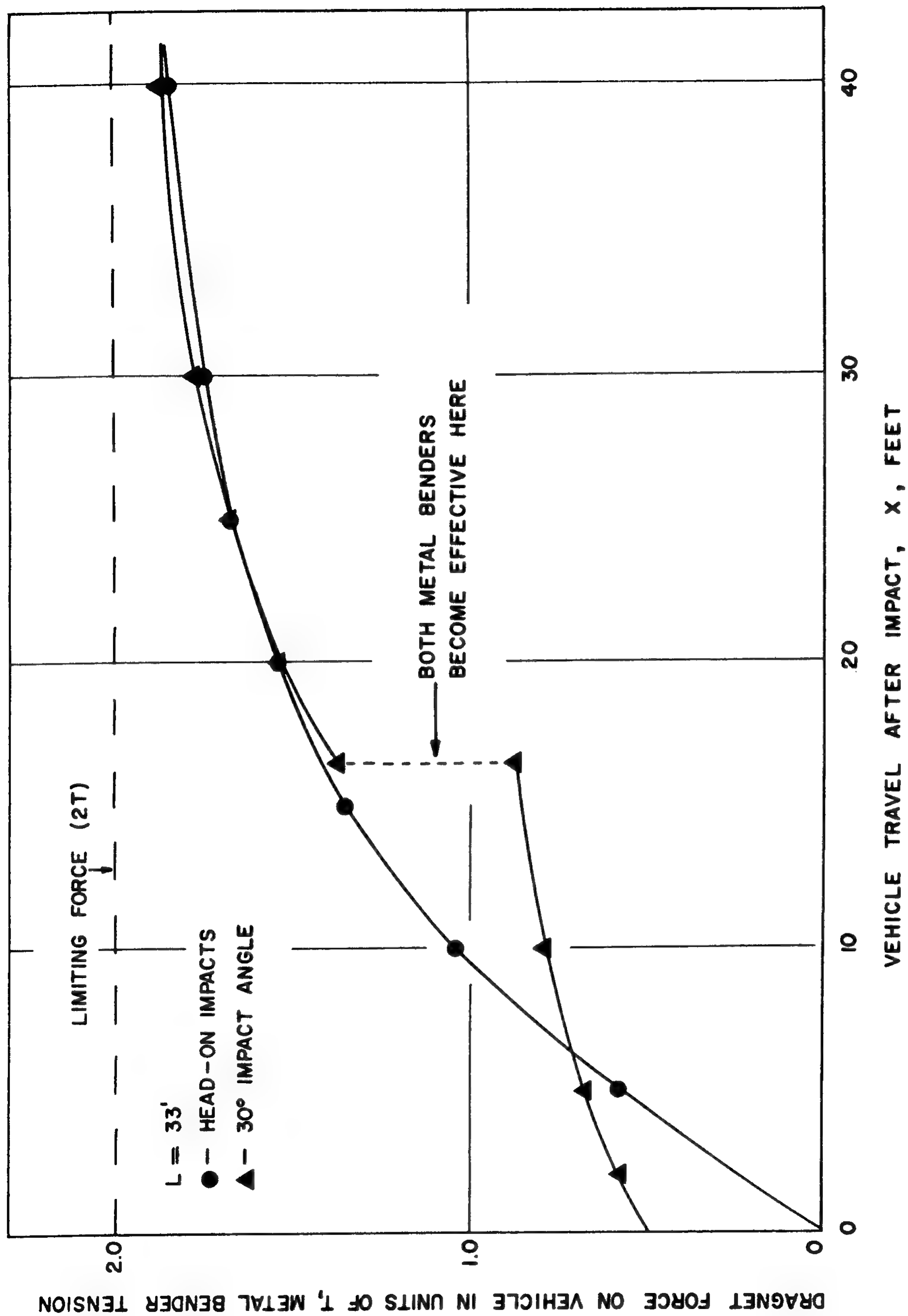


FIGURE 27, THEORETICAL STOPPING FORCE — DISPLACEMENT CURVES FOR CENTRIC IMPACTS

TABLE 5

Comparison of Vehicle Kinetic Energies
with Calculated Energy Expenditures
(in Kip-ft)

| Test No. | 4A | 4B | 4C | 4D | 4E | 4F |
|---|---|---|---|---|---|---|
| Initial Kinetic Energy of Vehicle | 87.1 | 513 | 123 | 437 | 401 | 464* |
| Energy Expended by Metal Benders (from measured tape pullout) | 54.8 | 296 | 85.5 | 214 | 384 | 411* |
| Energy from area under Force-Displacement curve in Figure 27. (Stopping distance from high speed films) | 140 | 450 | 105 | 440 | 365 | 330* |

* To expenditure of tape in right hand Metal Bender.

tension should equal the total tape pullout. By taking the initial velocity, determined from the high-speed films, and calculating initial kinetic energy, and by knowing the Metal Bender tape tensions, we can calculate the theoretical total tape pullout. Using this value and Figure 28, we can determine theoretical stopping distance. The theoretical stopping distances so determined are compared with actual stopping distances from the high-speed film data in Table 6. In this comparison, the measured stopping distance is the measured stopping distance of the vehicle's center of gravity minus the vehicle's deformation. (This is the distance traveled by the vehicle's front end after contacting the net.)

Again the percentage difference between actual and theoretical values is greater for short stopping distances (high Metal Bender tensions). An examination of the high-speed films indicates that in Test 4C the combination of the low, narrow front end of the vehicle and the collapse of the end net spreaders, which occurred in every test, delays application of the main stopping force until the vehicle has traveled about four feet beyond initial contact. This is a considerable portion of the total stopping distance, and explains the large difference between measured and calculated stopping distance. For this vehicle's initial energy, the calculated total tape pullout is 4.9 feet. This compares favorably with the actual measured tape pullout of 3.4 feet. The theoretical calculations are applied to an example design problem in Appendix B.

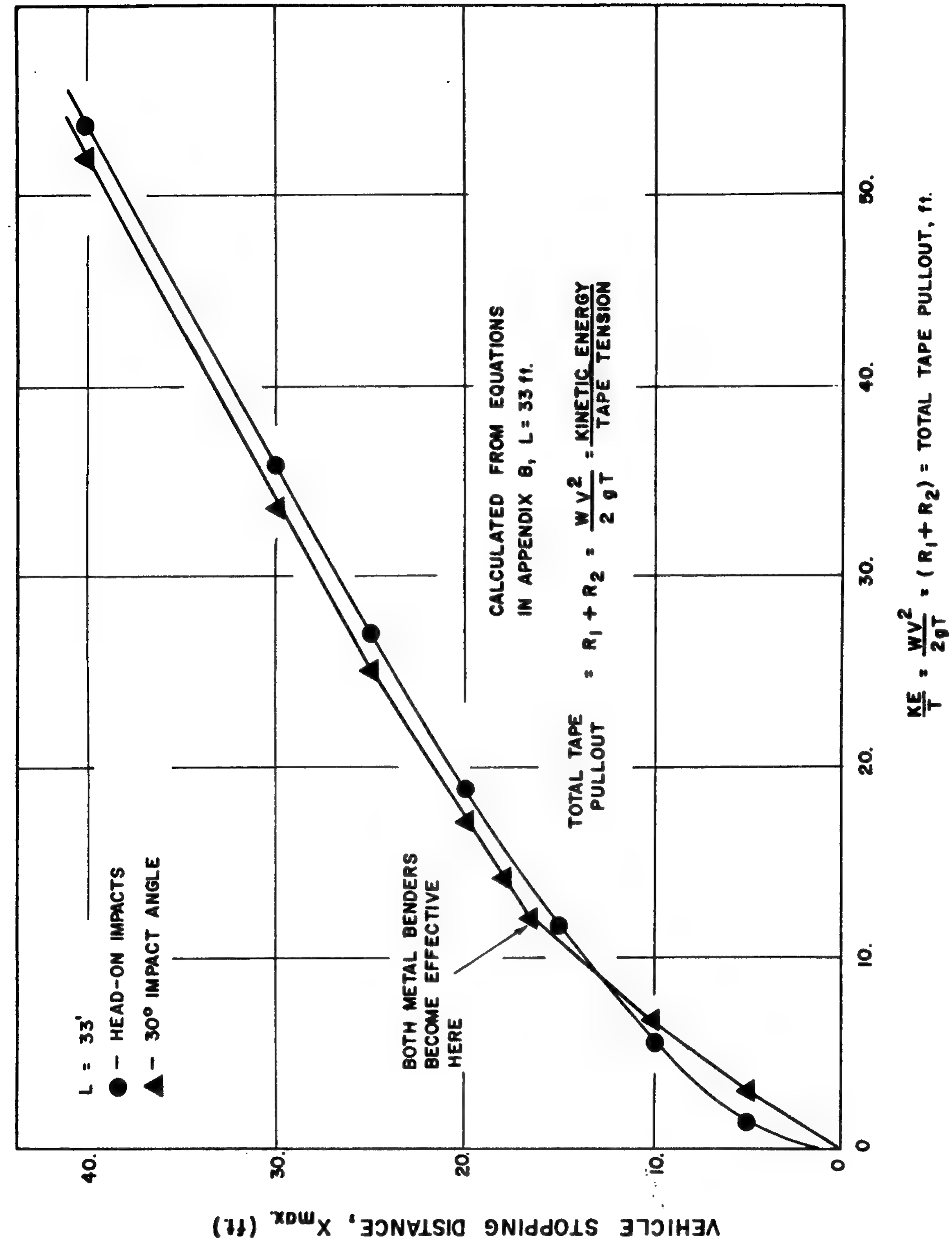


FIGURE 28, STOPPING DISTANCE VS. TOTAL TAPE PULLOUT



000583

TABLE 6

Comparison of Computed Stopping Distances
with Measured Stopping Distances

| Test No. | 4A | 4B | 4C | 4D | 4E | 4F |
|---|---|---|---|---|---|---|
| $(X_{max})_M$ (ft) ** | 8.4 | 18.4 | 12.9 | 22.0 | 26.0 | 29.0* |
| $(X_{max})_C$ (ft) *** | 7.8 | 21.0 | 7.6 | 20.2 | 27.7 | 29.5* |
| $\left[ (X_{max})_C - (X_{max})_M \right]$ (ft) | -0.6 | +2.6 | -5.3 | -1.8 | +1.7 | +0.5* |

* Calculated up to point metal tape was expended.

** Measured stopping distance from film minus vehicle deformation.

*** Calculated stopping distance from initial vehicle velocity and theoretical treatment in appendix.

# APPENDIX A

Design and Installation

Data

VAN ZELM Associates INC.
DEVELOPMENT ENGINEERS

1475 ELMWOOD AVENUE
PROVIDENCE, RHODE ISLAND 02907
TEL. (401) 781-3500

May 13, 1968
Serial Number S-305

Mr. T. J. Hirsch
Head, Structural Research Department
Texas A&M University
College of Engineering
College Station, Texas 77843

Dear Mr. Hirsch:

This letter supplements the previous information transmitted to you by our letter of April 29, 1968 and answers your telephone request of May 1.

Van Zelm has several Metal Bender Units which have been developed and tested and are adaptable for highway use. These units, with their pertinent physical and operational characteristics are presented below.

| Torture Chamber Mod. No. | Tape Size | Tape Load | Tape Nominal Runout | Max. Runout Possible |
|---|---|---|---|---|
| Std. Dragnet-MBP-1 | 1-1/4X.050 | 2500# | 200 Ft. | 500 Ft. |
| " " -MBP-2 | 2" X .050 | 2000# or 4000# | 400 Ft. | 1000 Ft. |
| Texas A&M Config. | 2" X 3/8 | 25,000# | 12.3 Ft. | 18.7 Ft. |
| " " " | 1-1/2"X3/8 | 18,500# | 18.7 Ft. | 18.7 Ft. |
| " " " | 1 X 3/8 | 12,500# | 18.7 Ft. | 18.7 Ft.* |

Units may be combined to produce a desired tape load which falls between the loads produced by the basic units. For example two 4000 lb. units may be combined to produce an 8000 lb. load or a 4000 lb. unit and a 2500 lb. unit a 6500 lb. load.

Also attached is one copy of Van Zelm drawing lE-2909 detailing the dragnet test installation at T.T.I.

Very truly yours,

L. Montanaro

L. Montanaro

LM:lt

* The tapes used in Tests 4E and 4F were 25 feet in length.

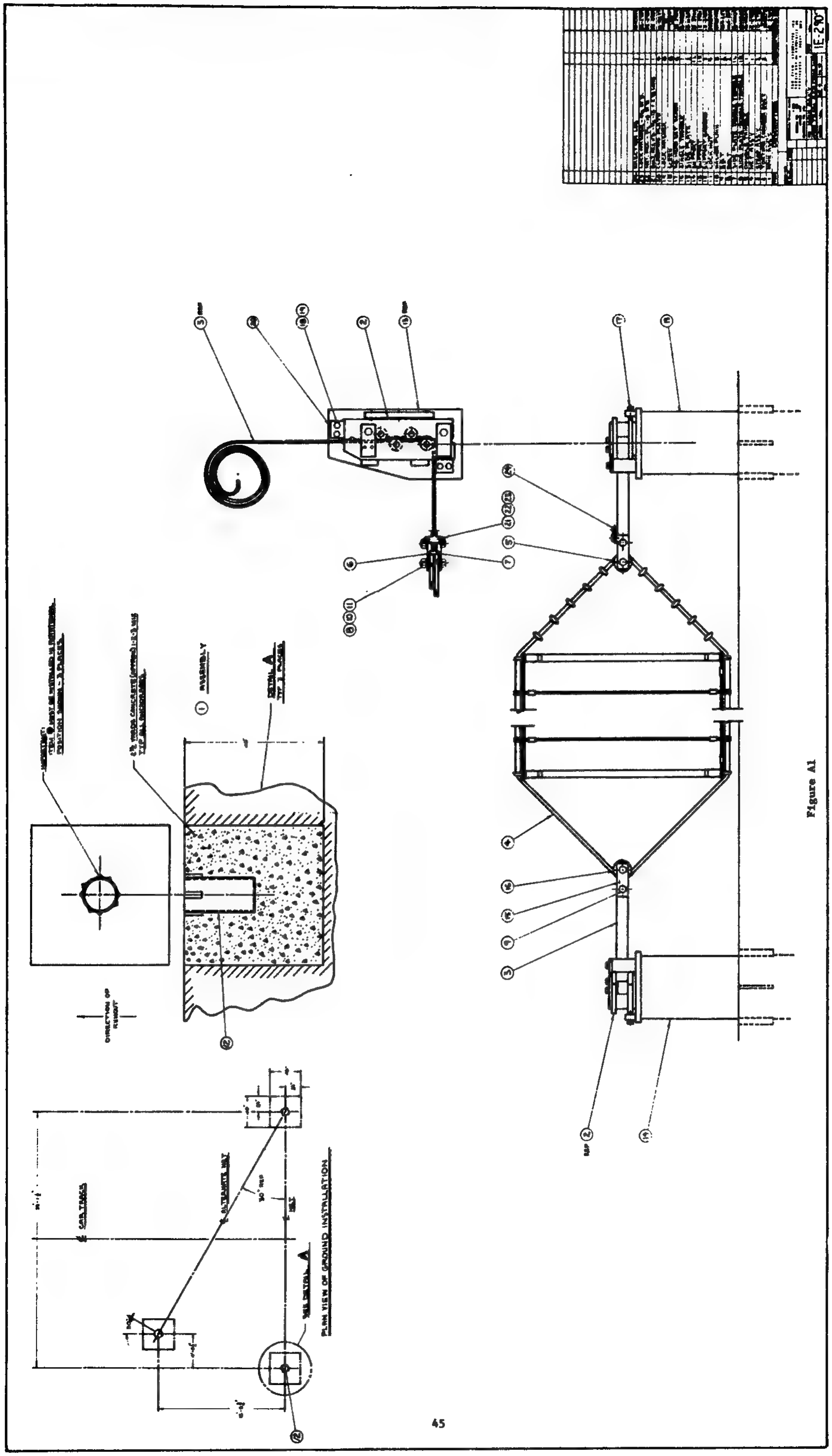

Figure A1



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# A P P E N D I X   B

Theory and Design

Example

EQUATIONS FOR ANALYSIS OF VAN ZELM METAL BENDER DRAGNET SYSTEM

HEAD-ON CENTRIC VEHICLE COLLISION

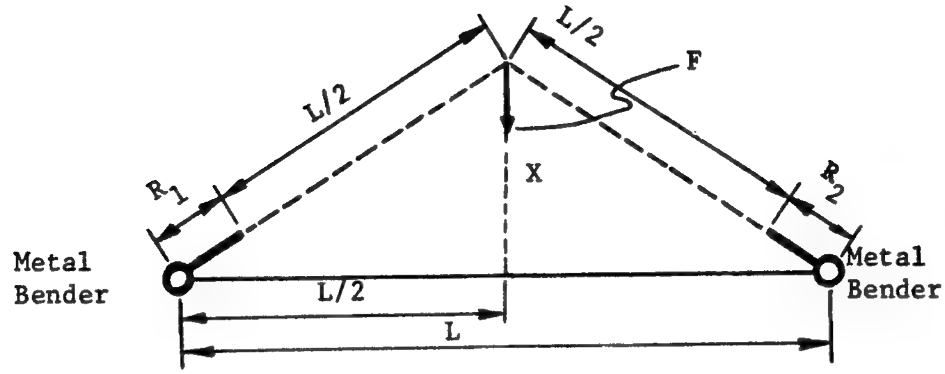



Figure B1

L = length of net, ft.

T = metal bender tape tension force, lb.

R = $R_1$ = $R_2$ = run out of metal bender tape (assuming all energy is absorbed by tape), ft.

X = travel distance of vehicle after engaging net, ft.

$X_{max}$ = stopping distance, ft.

F = stopping force component on vehicle, lb.

W = weight of vehicle, lb.

V = initial velocity of vehicle, ft/sec.

g = acceleration due to gravity, 32.2 ft/sec$^2$.

Relatively simple equations will now be developed which will aid in selecting a desirable metal bending tape tension force (T) and length ($R_{max}$) in order to stop a given vehicle of weight (W) and speed (V).

Van Zelm now has available metal tapes and metal benders (sometimes called "torture chambers") which provide tape tension forces (T) of 2,500 lb., 4,000 lb., 12,500 lb., 18,750 lb., and 25,000 lb. Two of the 4,000 lb. metal benders can be stacked on top of each other to provide a tape tension force of 8,000 lb.

For these tape tension forces, we can compute the minimum required length of tape (R), the stopping distance required ($X_{max}$), the maximum and average g forces on the vehicle as follows:

$$\text{Kinetic Energy of Vehicle} = \frac{WV^2}{2g}$$

Assuming all energy is absorbed by metal tape will yield the energy absorbed by metal bender tape = 2TR

Because of symmetry $R = R_1 = R_2$

$$\text{so} \quad 2TR_{max} = \frac{WV^2}{2g}$$

The maximum tape run out is then

(1) $$R_{max} = \frac{WV^2}{4Tg} \quad \text{and} \quad R_{max} = R_{1max} = R_{2max}$$

since system is symmetrical in this case.

From Figure B1,

(2) $$X = \sqrt{\left(R + \frac{L}{2}\right)^2 - \left(\frac{L}{2}\right)^2}$$

(2b) $$X_{max} = \sqrt{R_{max}^2 + R_{max} L}$$ Where $X_{max}$ is the stopping distance required for head-on collision.

The stopping force component on the vehicle is,

(3) $$F = 2T \left( \frac{X}{R + \frac{L}{2}} \right)$$

(3b) $$F_{max} = 2T \left( \frac{X_{max}}{R_{max} + \frac{L}{2}} \right)$$ Maximum vehicle stopping force for head-on collision.

The maximum G force on the vehicle is,

(4) $$G_{max} = \frac{F_{max}}{W}$$

The average G force on the vehicle would be,

(5) $$G_{avg} = \frac{V^2}{2gX_{max}}$$

A graph of F vs. X would be as shown below

$$F = 2T \left( \frac{X}{R + \frac{L}{2}} \right)$$

From Equation 2,

$$R = \frac{1}{2} \sqrt{L^2 + 4X^2} - \frac{L}{2}$$

so

(6) $$F = 2T \left( \frac{1}{\sqrt{\left(\frac{L}{2X}\right)^2 + 1}} \right)$$

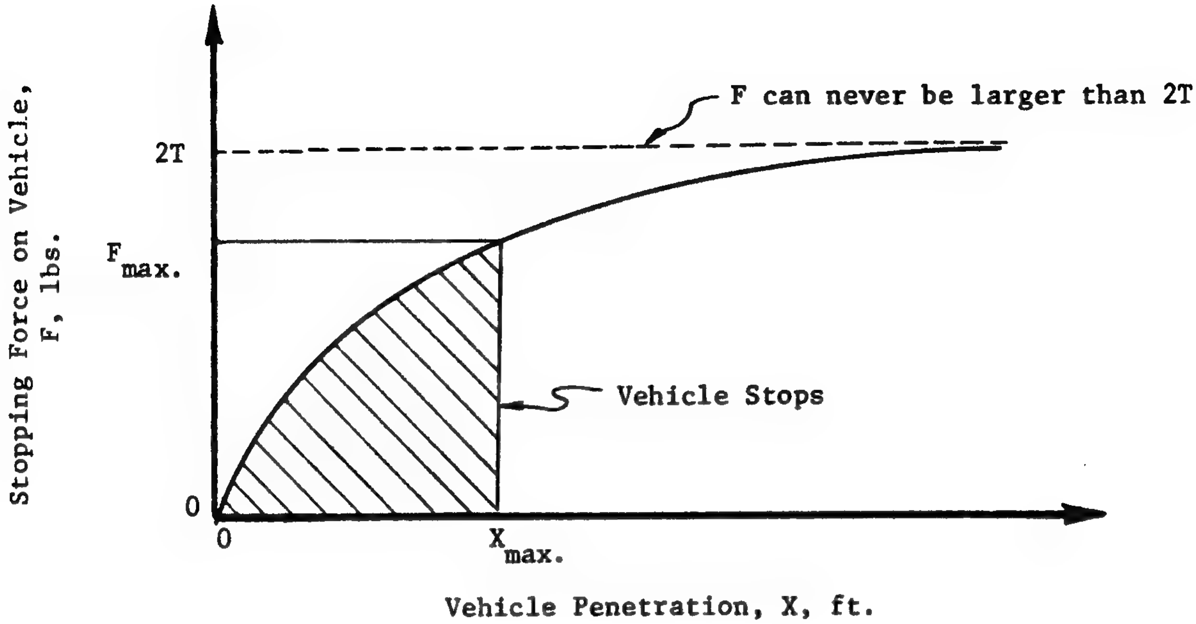



Figure B2, Idealized Vehicle Stopping Force vs. Stopping Distance

The preceding analysis applied to the special case of the "Dragnet" system being struck by a vehicle head-on and in the center. When the vehicle strikes the "Dragnet" at an angle, the mathematics becomes a little more complicated. An analysis of this problem will now be presented.

Idealized analysis of Van Zelm Metal Bender Dragnet Arresting System for centric vehicle collisions at any angle Θ.

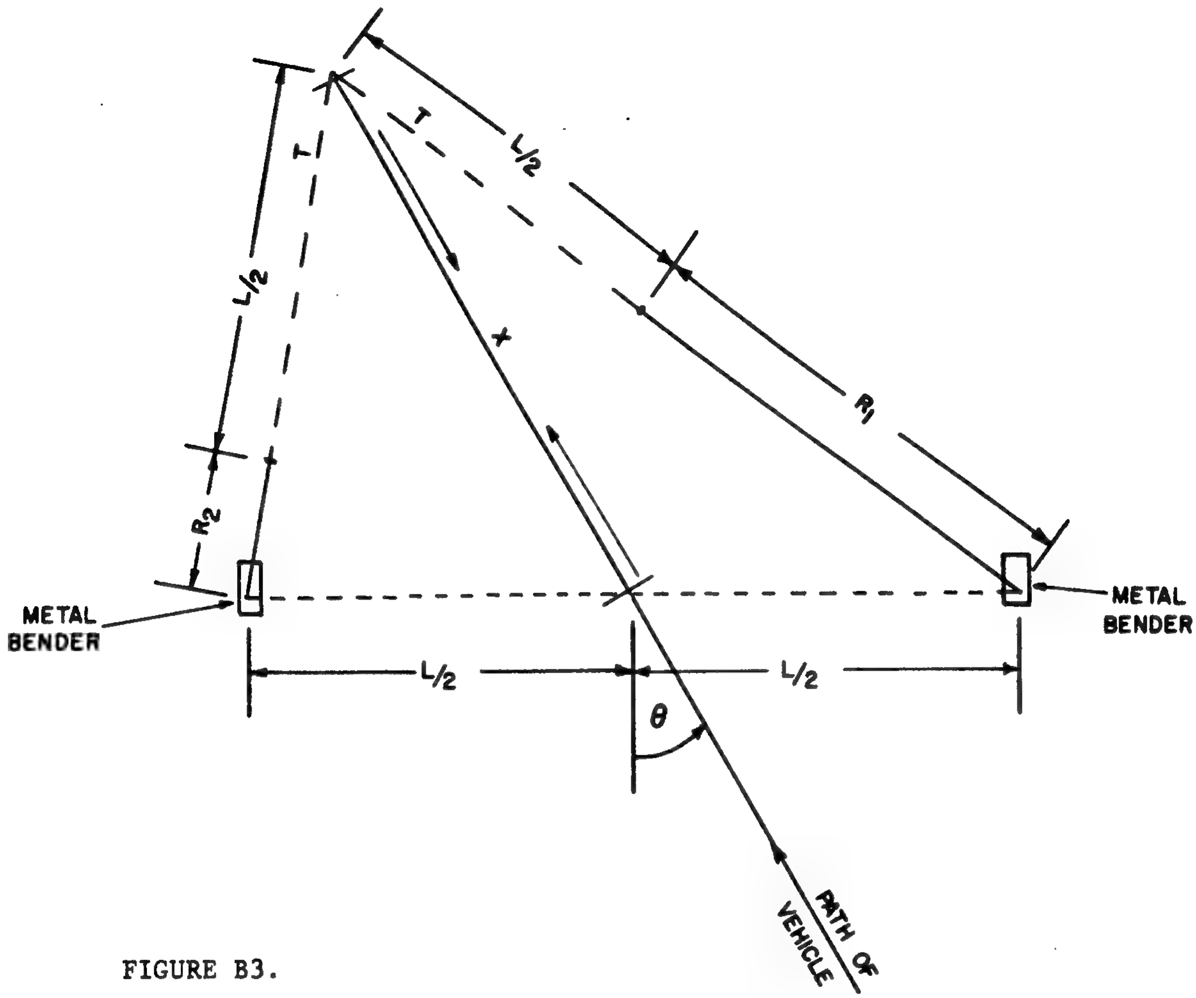



FIGURE B3.

L = Initial length of net <u>and</u> tape between Metal Benders, ft.

T = Metal Bender tape tension, Kip.

$R_1$ and $R_2$ = Metal Bender tape runouts, ft.

X = Travel of vehicle along original path after contacting the net, ft.

Xmax = Stopping distance after contacting net, ft.

$F_x$ = Stopping force componet along X, Kip.

W = Weight of vehicle, Kip.

V = Speed of vehicle at impact, ft/sec.

g = Acceleration due to gravity, 32.2 ft/sec$^2$.

θ = Impact angle, degrees.

Note: It is assumed that $R_2 = 0$ for $X \leq L \sin \theta$. (Derived from Law of Sines.)

Referring to Figure B3, the Pythagorean Theorem gives:

$$\left(R_1 + \frac{L}{2}\right)^2 = \left(\frac{L}{2} + X\sin\theta\right)^2 + \left(X\cos\theta\right)^2$$

This reduces to:

(7) $$R_1 = \left(\frac{L^2}{4} + X^2 + LX\sin\theta\right)^{1/2} - \frac{L}{2}$$

Similarly,

(8) $$R_2 = \left(\frac{L^2}{4} + X^2 - LX\sin\theta\right)^{1/2} - \frac{L}{2} \qquad \text{(for } X > L\sin\theta\text{)}$$

$$R_2 = 0 \qquad \text{(for } X \leqslant L\sin\theta\text{)}$$

Equations 7 and 8 can be solved for X in terms of $R_1$ or $R_2$:

(9) $$X = \left(\frac{L^2}{4}\sin^2\theta + R_1{}^2 + LR_1\right)^{1/2} - \frac{L}{2}\sin\theta$$

or $$X = \left(\frac{L^2}{4}\sin^2\theta + R_2{}^2 + LR_2\right)^{1/2} + \frac{L}{2}\sin\theta \qquad \text{(for } X > L\sin\theta\text{)}$$

The vehicle kinetic energy is related to the theoretical total strap pullout by:

(10) $$KE = \frac{WV^2}{2g} = T\,(R_{1_{max}} + R_{2_{max}}) \qquad \text{(when } \theta \text{ not equal to zero)}$$

or $$KE = \frac{WV^2}{2g} = 2TR_{max} \qquad \text{(for } \theta = 0°\text{)}$$

since $R_{1_{max}} = R_{2_{max}} = R_{max}$ because of symmetry of the system when $\theta = 0°$

The component of Metal Bender stopping force along X due to $R_1$ is:

$$F_{R_1} = T\left[\frac{X + \frac{L}{2}\sin\theta}{R_1 + \frac{L}{2}}\right] = T\left[\frac{X + \frac{L}{2}\sin\theta}{\sqrt{\frac{L^2}{4} + X^2 + LX\sin\theta}}\right] \tag{11}$$

Similarly,

$$F_{R_2} = T\left[\frac{X - \frac{L}{2}\sin\theta}{R_2 + \frac{L}{2}}\right] = T\left[\frac{X - \frac{L}{2}\sin\theta}{\sqrt{\frac{L^2}{4} + X^2 - LX\sin\theta}}\right] \tag{12}$$

The total stopping force along X is: (for $X > L\sin\theta$),

$$F_T = F_{R_1} + F_{R_2} = T\left[\frac{X + \frac{L}{2}\sin\theta}{\sqrt{\frac{L^2}{4} + X^2 + LX\sin\theta}} + \frac{X - \frac{L}{2}\sin\theta}{\sqrt{\frac{L^2}{4} + X^2 - LX\sin\theta}}\right] \tag{13}$$

$$F_T = F_{R_1} = T\left[\frac{X + \frac{L}{2}\sin\theta}{\sqrt{\frac{L^2}{4} + X^2 + LX\sin\theta}}\right] \qquad (\text{for } X \leqslant L\sin\theta) \tag{14}$$

If all the vehicle's kinetic energy is absorbed by the Metal Bender tape pullout, then

$$KE = \frac{WV^2}{2g} = \int_0^{X_{max}} F_T\, dx$$

$$= T\int_0^{X_{max}}\left[\frac{X + \frac{L}{2}\sin\theta}{\sqrt{\frac{L^2}{4} + X^2 + LX\sin\theta}}\right]dx + T\int_{L\sin\theta}^{X_{max}}\left[\frac{X - \frac{L}{2}\sin\theta}{\sqrt{\frac{L^2}{4} + X^2 - LX\sin\theta}}\right]dx$$

(for $X > L\sin\theta$)

Let $\left(\frac{L^2}{4} + X^2 + L\,X\sin\theta\right) = u, \quad$ and $\left(\frac{L^2}{4} + X^2 - L\,X\sin\theta\right) = v$

Then $du = (2X + L\sin\theta)dx, \quad$ and $\quad dv = (2X - L\sin\theta)dx$

Therefore,

$$KE = \frac{WV^2}{2g} = \frac{T}{2}\int_{u_i}^{u_f} u^{-1/2}\,du + \frac{T}{2}\int_{v_i}^{v_f} v^{-1/2}\,dv$$

$$= \frac{T}{2}\left(2u^{1/2} + 2v^{1/2}\right)_{\text{initial}}^{\text{final}}$$

$$= T\left(\sqrt{\frac{L^2}{4} + X^2 + L\,X\sin\theta}\;\Bigg|_0^{X_{max}} + \sqrt{\frac{L^2}{4} + X^2 - L\,X\sin\theta}\;\Bigg|_{L\sin\theta}^{X_{max}}\right)$$

$$= T\left(\sqrt{\frac{L^2}{4} + X_{max}^2 + L\,X_{max}\sin\theta} + \sqrt{\frac{L^2}{4} + X_{max}^2 - L\,X_{max}\sin\theta} - \frac{L}{2} - \frac{L}{2}\right)$$

Or,

(15) $$KE = \frac{WV^2}{2g} = T\left(\sqrt{\frac{L^2}{4} + X_{max}^2 + L\,X_{max}\sin\theta} + \sqrt{\frac{L^2}{4} + X_{max}^2 - L\,X_{max}\sin\theta} - L\right)$$

(for $X_{max} > L\sin\theta$)

(16) $$\frac{WV^2}{2g} = T\left(\sqrt{\frac{L^2}{4} + X_{max}^2 + L\,X_{max}\sin\theta} - \frac{L}{2}\right)$$ (for $X_{max} < L\sin\theta$)

Note that the expression for total energy obtained by integration of $F_T dx$ (Equation 15) is equal to $T(R_1 + R_2)$ using Equations 7 and 8.

For $\theta = 30°$ (Tests 4C, 4D and 4F), Equations 7, 8, 9, 15 and 16 become, respectively,

$$(17) \qquad R_1 = \left[\frac{L^2}{4} + X^2 + \frac{L\,X}{2}\right]^{1/2} - \frac{L}{2}$$

$$(18) \qquad R_2 = \left[\frac{L^2}{4} + X^2 - \frac{L\,X}{2}\right]^{1/2} - \frac{L}{2}$$

$$(19) \qquad X = \left[\left(\frac{L}{4}\right)^2 + R_1{}^2 + L R_1\right]^{1/2} - \frac{L}{4} \qquad \text{(in terms of } R_1\text{)}$$

$$\text{or} \qquad X = \left[\left(\frac{L}{4}\right)^2 + R_2{}^2 + R_2\,L\right]^{1/2} + \frac{L}{4} \qquad \text{(in terms of } R_2 \text{ if } X > \tfrac{L}{2}\text{)}$$

$$(20) \qquad \frac{WV^2}{2g} = T\left[\sqrt{\frac{L^2}{4} + X_{max}^2 + \frac{L\,X_{max}}{2}} + \sqrt{\frac{L^2}{4} + X_{max}^2 - \frac{L\,X_{max}}{2}} - L\right] \qquad \text{(for } X > \tfrac{L}{2}\text{)}$$

$$(21) \qquad \frac{WV^2}{2g} = T\left[\sqrt{\frac{L^2}{4} + X_{max}^2 + \frac{L\,X_{max}}{2}} - \frac{L}{2}\right] \qquad \text{(for } X \leq \tfrac{L}{2}\text{)}$$

For $\theta = 0°$ (Tests 4A, 4B and 4E), Equations 7 and 8 become,

$$(22) \qquad R_1 = R_2 = R = \left[\frac{L^2}{4} + X^2\right]^{1/2} - \frac{L}{2}$$

And Equation 15 becomes,

$$(23) \qquad \frac{WV^2}{2g} = 2T\left(\sqrt{\frac{L^2}{4} + X_{max}^2} - \frac{L}{2}\right)$$

From Equation 23,

$$X_{max}^2 = \left(\frac{KE}{2T} + \frac{L}{2}\right)^2 - \frac{L^2}{4} = \left(\frac{KE}{2T}\right)^2 + \left(\frac{KE}{2T}\right)L$$

$$(24) \qquad X_{max} = \sqrt{\left(\frac{WV^2}{4gT}\right)\left(\frac{WV^2}{4gT} + L\right)}$$

For head-on impacts, theoretical $X_{max}$ can be determined from Equation 24. For 30° angled impacts, see Figure 27.

## AN EXAMPLE OF HOW THESE EQUATIONS CAN BE APPLIED TO THE DESIGN OF AN ARRESTING SYSTEM USING VAN ZELM METAL BENDER ENERGY ABSORBING DEVICES

Given: Design factors dictate that the arresting system must stop vehicles with weights up to 4500 pounds and speeds up to 60 mph after en ering the system at angles of up to 20° with the perpendicular to the net. Geometric factors limit the distance between the end anchor posts to 30 feet and the maximum stopping distance to 30 feet.

Problem: What is the required minimum Metal Bender tape tension and tape lengths.

Solution: (See formulas on pages 51 through 54). The total tape pullout, for a particular energy and tension, is about the same regardless of the angle of impact. However, a preliminary calculation, using Equations 7, 8, and 9, shows that the stopping distance is greatest for $\theta = 20°$. Therefore use $\theta = \theta_{max} = 20°$ as a limiting case.

The critical design factors are:

$\theta_{max} = 20°$ $\quad$ ($\sin \theta_{max} = 0.342$)

$X_{max} = 30$ feet

$L = 30$ feet

Using these values in Equations 7 and 8:

$$R_{1max} = \left[ \frac{L^2}{4} + X^2_{max} + L X_{max} \sin\theta \right]^{1/2} - \frac{L}{2}$$

$$= \left[ 225 + 900 + 308 \right]^{1/2} - 15$$

$$= 37.9 - 15 = 22.9 \text{ feet}$$

$$R_{2max} = \left[ \frac{L^2}{4} + X^2_{max} - L X_{max} \sin\theta \right]^{1/2} - \frac{L}{2}$$

$$= \left[ 225 + 900 - 308 \right]^{1/2} - 15$$

$$= 28.6 - 15 = 13.6 \text{ feet}$$

The minimum tape length is $R_{1max}$ = 23 feet, (approximately)

Total tape pullout = (22.9 + 13.6)feet = 36.5 feet.

The maximum vehicle kinetic energy is:

$$\frac{WV^2}{2g} = \frac{(4500)\ (88)^2}{64.4} \text{ foot-pounds} = 542{,}000 \text{ foot-pounds}$$

From Equation 10,

$$T_{min.} = \left(\frac{WV^2}{2g}\right) \left(\frac{1}{R_{1max} + R_{2max}}\right)$$

$$= \frac{542{,}000}{36.5} \text{ pounds} = 14{,}850 \text{ pounds}$$

Theoretically the minimum Metal Bender tape tension is 14,850 pounds and the minimum length of tape required for runout in each Metal Bender is about 23 feet. The Metal Bender tape tension should now be chosen on the basis of the available tape tensions, including some excess tape length as a safety factor.

# <u>APPENDIX</u> <u>C</u>

## Photographic and Electromechanical

## Test Data

TABLE C1

TEST RF 505-4A

VAN ZELM METAL BENDER, HEAD-ON

1958 RENAULT, 4 DOOR SEDAN, 1460 LB.

HIGH SPEED FILM DATA

| Time Milliseconds | | Displacement ft | Velocity ft/sec |
|---|---|---|---|
| 0 | | 0 | |
| | | | 59.8 |
| 11.70 | | 0.70 | |
| | | | 57.3 |
| 23.40 | | 1.37 | |
| | | | 68.4 |
| 35.10 | Impact | 2.17 | |
| | | | 59.0 |
| 46.80 | | 2.86 | |
| | | | 63.3 |
| 58.50 | | 3.60 | |
| | | | 63.3 |
| 70.20 | | 4.34 | |
| | | | 55.6 |
| 81.90 | | 4.99 | |
| | | | 59.8 |
| 93.60 | | 5.69 | |
| | | | 56.4 |
| 105.30 | | 6.35 | |
| | | | 55.6 |
| 117.00 | | 7.00 | |
| | | | 55.6 |
| 128.70 | | 7.65 | |
| | | | 55.6 |
| 140.40 | | 8.30 | |
| | | | 44.4 |
| 152.10 | | 8.82 | |
| | | | 47.8 |
| 163.80 | | 9.38 | |
| | | | 47.1 |
| 175.50 | | 9.93 | |
| | | | 37.6 |
| 187.20 | | 10.37 | |
| | | | 38.5 |
| 198.90 | | 10.82 | |
| | | | 33.4 |
| 210.60 | | 11.21 | |
| | | | 24.8 |
| 222.30 | | 11.50 | |

TABLE C1

TEST RF 505-4A (continued)

| Time Milliseconds | Displacement ft | Velocity ft/sec |
|---|---|---|
| | | 25.6 |
| 234.00 | 11.80 | |
| | | 18.8 |
| 245.70 | 12.02 | |
| | | 11.1 |
| 257.40 | 12.15 | |
| | | 8.6 |
| 269.10 | 12.25 | |
| | | 6.0 |
| 280.80 | 12.32 | |
| | | 0.0 |
| 292.50 | 12.32 | |

TABLE C2

TEST RF 505-4B

VAN ZELM METAL BENDER, HEAD-ON

1960 MERCURY, 4 DOOR SEDAN, 4300 LB.

HIGH SPEED FILM DATA

| Time Milliseconds | | Displacement ft | Velocity ft/sec |
|---|---|---|---|
| 0 | | 0 | |
| | | | 86.2 |
| 13.00 | | 1.12 | |
| | | | 90.0 |
| 26.00 | | 2.29 | |
| | | | 86.2 |
| 39.00 | Impact | 3.41 | |
| | | | 83.0 |
| 52.00 | | 4.49 | |
| | | | 87.7 |
| 65.00 | | 5.63 | |
| | | | 83.9 |
| 78.00 | | 6.72 | |
| | | | 86.2 |
| 91.00 | | 7.84 | |
| | | | 80.7 |
| 104.00 | | 8.89 | |
| | | | 78.5 |
| 117.00 | | 9.91 | |
| | | | 78.5 |
| 130.00 | | 10.93 | |
| | | | 73.1 |
| 143.00 | | 11.88 | |
| | | | 73.1 |
| 156.00 | | 12.83 | |
| | | | 70.0 |
| 169.00 | | 13.74 | |
| | | | 66.1 |
| 182.00 | | 14.60 | |
| | | | 64.6 |
| 195.00 | | 15.44 | |
| | | | 65.4 |
| 208.00 | | 16.29 | |
| | | | 56.2 |
| 221.00 | | 17.02 | |
| | | | 57.0 |
| 234.00 | | 17.76 | |
| | | | 54.6 |
| 247.00 | | 18.47 | |
| | | | 46.2 |
| 260.00 | | 19.07 | |

TABLE C2

TEST RF 505-4B (continued)

| Time Milliseconds | Displacement ft | Velocity ft/sec |
|---|---|---|
| | | 46.2 |
| 273.00 | 19.67 | |
| | | 43.9 |
| 286.00 | 20.24 | |
| | | 38.5 |
| 299.00 | 20.74 | |
| | | 33.9 |
| 312.00 | 21.18 | |
| | | 28.5 |
| 325.00 | 21.55 | |
| | | 23.1 |
| 338.00 | 21.85 | |
| | | 20.8 |
| 351.00 | 22.12 | |
| | | 16.1 |
| 364.00 | 22.33 | |
| | | 12.3 |
| 377.00 | 22.49 | |
| | | 12.3 |
| 390.00 | 22.65 | |
| | | 6.2 |
| 403.00 | 22.73 | |
| | | 3.8 |
| 416.00 | 22.78 | |
| | | 2.3 |
| 429.00 | 22.81 | |
| | | 0.0 |
| 442.00 | 22.81 | |

TABLE C3

TEST RF 505-4C

VAN ZELM METAL BENDER, 30$^\circ$ ANGLE

1955 VOLKSWAGEN, 2 DOOR, 1620 LB.

HIGH SPEED FILM DATA

| Time Milliseconds | | Displacement ft | Velocity ft/sec |
|---|---|---|---|
| 0 | | 0 | |
| | | | 70.8 |
| 12.00 | | 0.85 | |
| | | | 69.2 |
| 24.00 | | 1.68 | |
| | | | 69.2 |
| 36.00 | Impact | 2.51 | |
| | | | 65.8 |
| 48.00 | | 3.30 | |
| | | | 70.8 |
| 60.00 | | 4.15 | |
| | | | 69.2 |
| 72.00 | | 4.98 | |
| | | | 65.8 |
| 84.00 | | 5.77 | |
| | | | 65.8 |
| 96.00 | | 6.56 | |
| | | | 68.2 |
| 108.00 | | 7.38 | |
| | | | 67.4 |
| 120.00 | | 8.19 | |
| | | | 64.1 |
| 132.00 | | 8.96 | |
| | | | 65.8 |
| 144.00 | | 9.75 | |
| | | | 64.1 |
| 156.00 | | 10.52 | |
| | | | 59.1 |
| 168.00 | | 11.23 | |
| | | | 60.8 |
| 180.00 | | 11.96 | |
| | | | 46.6 |
| 192.00 | | 12.52 | |
| | | | 45.0 |
| 204.00 | | 13.06 | |
| | | | 46.6 |
| 216.00 | | 13.62 | |
| | | | 44.2 |
| 228.00 | | 14.15 | |
| | | | 41.6 |
| 240.00 | | 14.65 | |

TABLE C3

TEST RF 505-4C (continued)

| Time Milliseconds | Displacement ft | Velocity ft/sec |
|---|---|---|
| | | 37.5 |
| 252.00 | 15.10 | |
| | | 26.6 |
| 264.00 | 15.42 | |
| | | 26.6 |
| 276.00 | 15.74 | |
| | | 15.0 |
| 288.00 | 15.92 | |
| | | 17.5 |
| 300.00 | 16.13 | |
| | | 8.3 |
| 312.00 | 16.23 | |
| | | 5.8 |
| 324.00 | 16.30 | |
| | | 0.0 |
| 336.00 | 16.30 | |

TABLE C4

TEST RF 505-4D

VAN ZELM METAL BENDER, 30° ANGLE

1958 OLDSMOBILE, 4 DOOR, 4520 LB.

HIGH SPEED FILM DATA

| Time Milliseconds | | Displacement ft | Velocity ft/sec |
|---|---|---|---|
| 0 | | 0 | |
| | | | 78.2 |
| 11.90 | | 0.93 | |
| | | | 82.4 |
| 23.80 | | 1.91 | |
| | | | 74.8 |
| 35.70 | | 2.80 | |
| | | | 82.4 |
| 47.60 | | 3.78 | |
| | | | 75.6 |
| 59.50 | Impact | 4.68 | |
| | | | 80.7 |
| 71.40 | | 5.64 | |
| | | | 79.0 |
| 83.30 | | 6.58 | |
| | | | 77.3 |
| 95.20 | | 7.50 | |
| | | | 74.8 |
| 107.10 | | 8.39 | |
| | | | 77.3 |
| 119.00 | | 9.31 | |
| | | | 73.1 |
| 130.90 | | 10.18 | |
| | | | 78.1 |
| 142.80 | | 11.11 | |
| | | | 71.5 |
| 154.70 | | 11.96 | |
| | | | 79.8 |
| 166.60 | | 12.91 | |
| | | | 68.8 |
| 178.50 | | 13.73 | |
| | | | 73.1 |
| 190.40 | | 14.60 | |
| | | | 70.6 |
| 202.30 | | 15.44 | |
| | | | 69.8 |
| 214.20 | | 16.27 | |
| | | | 65.6 |
| 226.10 | | 17.05 | |
| | | | 60.5 |
| 238.00 | | 17.77 | |

TABLE C4

TEST RF 505-4D (continued)

| Time Milliseconds | Displacement ft | Velocity ft/sec |
|---|---|---|
| | | 68.1 |
| 249.90 | 18.58 | |
| | | 55.5 |
| 261.80 | 19.24 | |
| | | 57.2 |
| 273.70 | 19.92 | |
| | | 54.6 |
| 285.60 | 20.57 | |
| | | 50.4 |
| 297.50 | 21.17 | |
| | | 51.2 |
| 309.40 | 21.78 | |
| | | 42.8 |
| 321.30 | 22.29 | |
| | | 46.3 |
| 333.20 | 22.84 | |
| | | 34.5 |
| 345.10 | 23.25 | |
| | | 40.3 |
| 357.00 | 23.73 | |
| | | 31.9 |
| 368.90 | 24.11 | |
| | | 37.8 |
| 380.80 | 24.56 | |
| | | 21.0 |
| 392.70 | 24.81 | |
| | | 31.1 |
| 404.60 | 25.18 | |
| | | 23.5 |
| 416.50 | 25.46 | |
| | | 29.4 |
| 428.40 | 25.81 | |
| | | 26.9 |
| 440.30 | 26.13 | |
| | | 25.2 |
| 452.20 | 26.43 | |
| | | 18.5 |
| 464.10 | 26.65 | |
| | | 26.1 |
| 476.00 | 26.96 | |
| | | 23.5 |
| 487.90 | 27.24 | |
| | | 23.5 |
| 499.80 | 27.52 | |

TABLE C4

TEST RF 505-4D (continued)

| Time Milliseconds | Displacement ft | Velocity ft/sec |
|---|---|---|
| | | 16.8 |
| 511.70 | 27.72 | |
| | | 28.6 |
| 523.60 | 28.06 | |
| | | 10.9 |
| 535.50 | 28.19 | |
| | | 0.0 |
| 547.40 | 28.19 | |

TABLE C5

TEST RF 505-4E

VAN ZELM METAL BENDER, HEAD-ON

1961 DODGE, 4 DOOR, 3760 LB.

HIGH SPEED FILM DATA

| Time Milliseconds | | Displacement ft | Velocity ft/sec |
|---|---|---|---|
| 0 | | 0 | |
| | | | 90.8 |
| 12.59 | | 1.143 | |
| | | | 82.7 |
| 25.18 | | 2.184 | |
| | | | 88.3 |
| 37.77 | | 3.296 | |
| | | | 77.8 |
| 50.36 | | 4.276 | |
| | | | 75.4 |
| 62.95 | | 5.225 | |
| | | | 81.9 |
| 75.54 | | 6.256 | |
| | | | 81.0 |
| 88.13 | Impact | 7.276 | |
| | | | 80.2 |
| 100.72 | | 8.286 | |
| | | | 75.6 |
| 125.90 | | 10.189 | |
| | | | 78.6 |
| 151.08 | | 12.168 | |
| | | | 77.1 |
| 201.44 | | 16.050 | |
| | | | 67.4 |
| 251.80 | | 19.443 | |
| | | | 63.0 |
| 302.16 | | 22.616 | |
| | | | 56.1 |
| 352.52 | | 25.443 | |
| | | | 47.7 |
| 402.88 | | 27.846 | |
| | | | 37.5 |
| 453.24 | | 29.734 | |
| | | | 29.7 |
| 503.60 | | 31.230 | |
| | | | 21.6 |
| 553.96 | | 32.317 | |
| | | | 15.1 |
| 604.32 | | 33.078 | |

TABLE C5

TEST RF 505-4E (continued)

| Time Milliseconds | Displacement ft | Velocity ft/sec |
|---|---|---|
| | | 8.6 |
| 654.68 | 33.512 | |
| | | 2.1 |
| 705.04 | 33.619 | |
| | | 0.3 |
| 755.40 | 33.634 | |
| | | -2.6 |
| 805.76 | 33.501 | |
| | | -1.9 |
| 856.12 | 33.404 | |
| | | -3.2 |
| 906.48 | 33.241 | |
| | | -3.5 |
| 956.84 | 33.063 | |
| | | -3.2 |
| 1007.20 | 32.901 | |
| | | -3.0 |
| 1057.56 | 32.748 | |
| | | -4.0 |
| 1107.92 | 32.544 | |
| | | -4.5 |
| 1158.28 | 32.315 | |
| | | -3.4 |
| 1208.64 | 32.142 | |
| | | -3.6 |
| 1259.00 | 31.958 | |
| | | -6.4 |
| 1309.36 | 31.637 | |
| | | -4.0 |
| 1359.72 | 31.438 | |
| | | -5.2 |
| 1410.08 | 31.178 | |
| | | -5.4 |
| 1460.44 | 30.908 | |
| | | -3.0 |
| 1510.80 | 30.755 | |
| | | 0.0 |
| 1561.16 | 30.755 | |

TABLE C6

TEST RF 505-4F

HIGH SPEED FILM DATA

| Time Milliseconds | | Displacement ft | Velocity ft/sec |
|---|---|---|---|
| 0 | | 0 | |
| | | | 90.5 |
| 10.06 | | .910 | |
| | | | 91.6 |
| 20.12 | | 1.832 | |
| | | | 90.0 |
| 30.18 | | 2.738 | |
| | | | 95.6 |
| 40.24 | Impact | 3.700 | |
| | | | 87.3 |
| 60.36 | | 5.456 | |
| | | | 88.5 |
| 80.48 | | 7.236 | |
| | | | 85.3 |
| 100.60 | | 8.952 | |
| | | | 80.5 |
| 120.72 | | 10.572 | |
| | | | 81.9 |
| 140.84 | | 12.220 | |
| | | | 78.3 |
| 160.96 | | 13.795 | |
| | | | 77.5 |
| 181.08 | | 15.355 | |
| | | | 75.0 |
| 201.20 | | 16.863 | |
| | | | 68.7 |
| 221.32 | | 18.245 | |
| | | | 69.5 |
| 241.44 | | 19.643 | |
| | | | 66.5 |
| 261.56 | | 20.981 | |
| | | | 62.3 |
| 281.68 | | 22.235 | |
| | | | 61.9 |
| 301.80 | | 23.481 | |
| | | | 56.4 |
| 321.92 | | 24.615 | |
| | | | 54.2 |
| 342.04 | | 25.705 | |
| | | | 53.4 |
| 362.16 | | 26.779 | |
| | | | 48.4 |
| 382.28 | | 27.753 | |

TABLE C6

TEST RF 505-4F (continued)

| Time Milliseconds | Displacement ft | Velocity ft/sec |
|---|---|---|
| | | 46.8 |
| 402.40 | 28.695 | |
| | | 41.4 |
| 422.52 | 29.529 | |
| | | 40.8 |
| 442.64 | 30.351 | |
| | | 37.5 |
| 462.76 | 31.105 | |
| | | 32.5 |
| 482.88 | 31.759 | |
| | | 34.1 |
| 503.00 | 32.445 | |
| | | 28.5 |
| 523.12 | 33.018 | |
| | | 28.1 |
| 543.24 | 33.583 | |
| | | 25.4 |
| 563.36 | 34.095 | |
| | | 19.7 |
| 583.48 | 34.491 | |
| | | 24.5 |
| 603.60 | 34.984 | |
| | | 22.7 |
| 623.72 | 35.440 | |
| | | 18.3 |
| 643.84 | 35.808 | |
| | | 22.1 |
| 663.96 | 36.252 | |
| | | 17.7 |
| 684.08 | 36.608 | |
| | | 19.9 |
| 704.20 | 37.008 | |
| | | 16.1 |
| 724.32 | 37.332 | |
| | | 18.5 |
| 744.44 | 37.704 | |

Vehicle moved out of view

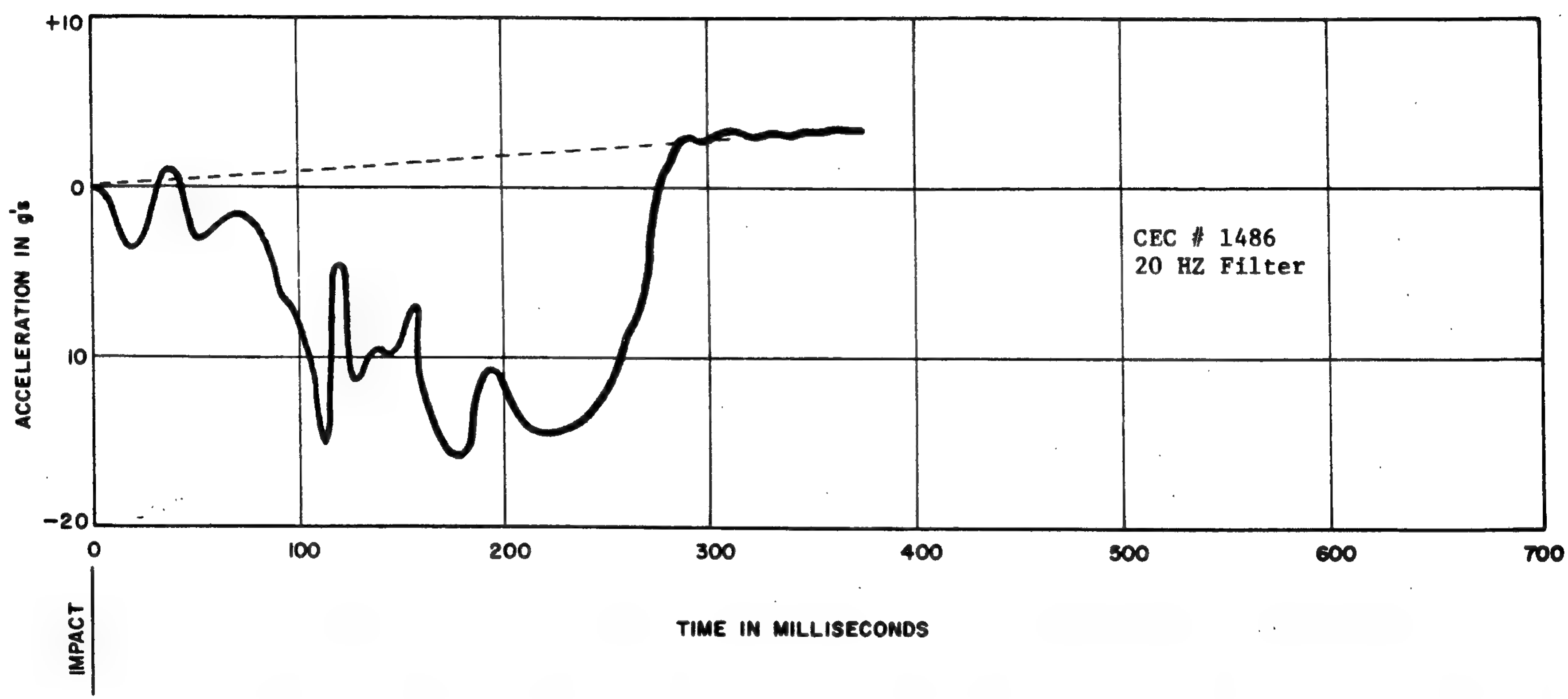



FIGURE C1, VEHICLE FRAME ACCELEROMETER DATA (LONGITUDINAL), TEST RF505-4A

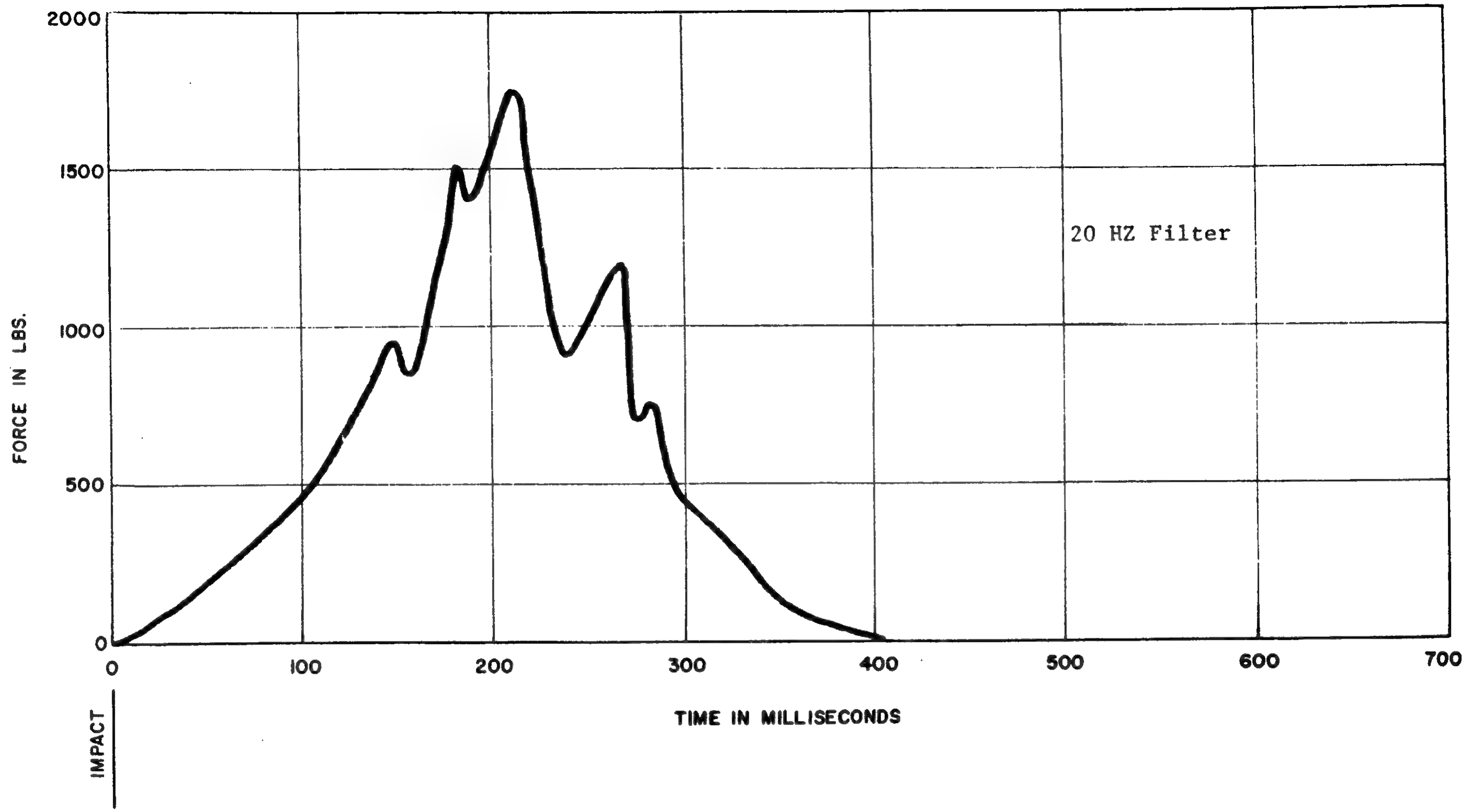



FIGURE C2, DUMMY SEATBELT FORCE DATA, TEST RF 505-4A

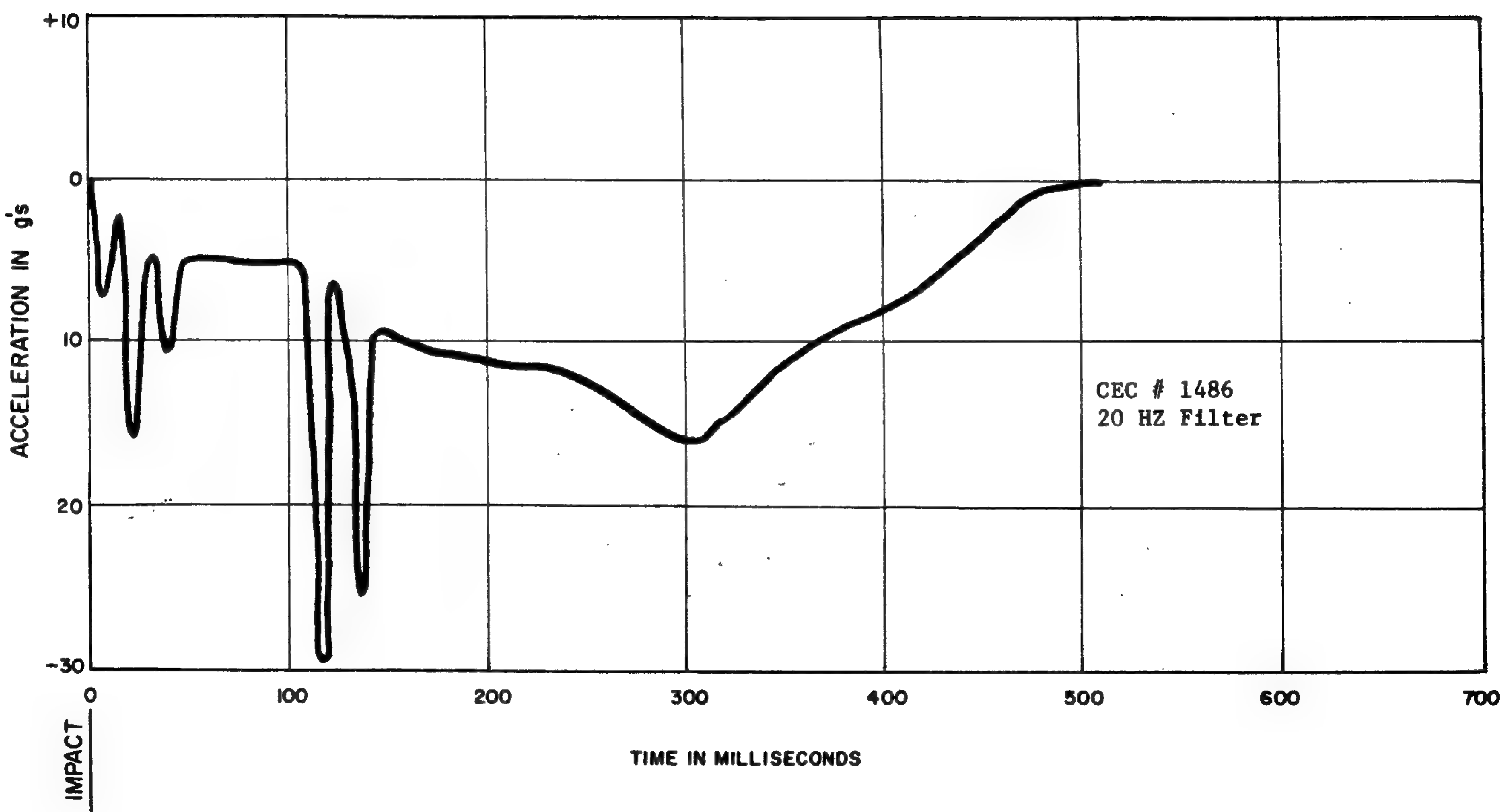



FIGURE C3, VEHICLE FRAME ACCELEROMETER DATA (LONGITUDINAL), TEST RF 505-4B

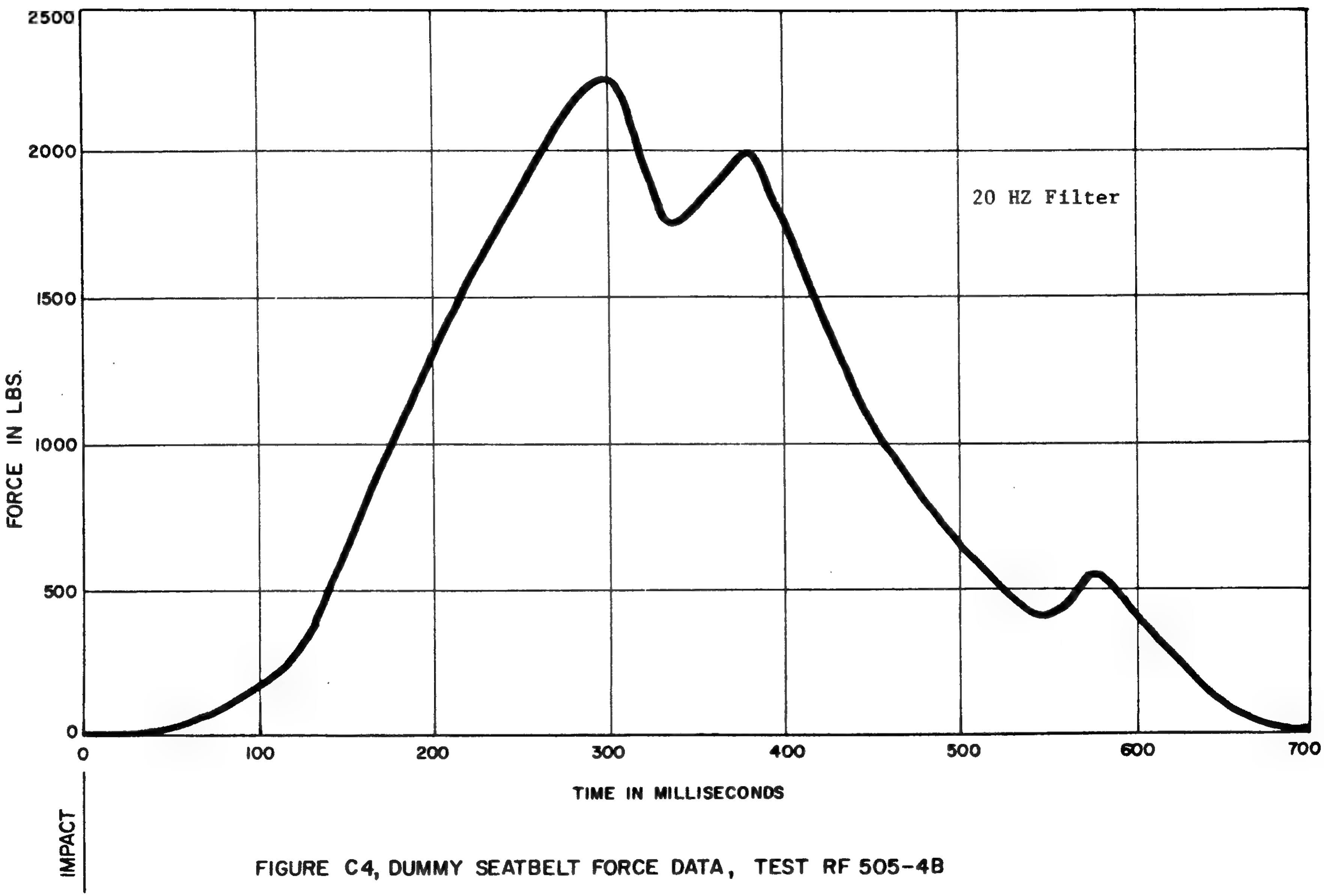



FIGURE C4, DUMMY SEATBELT FORCE DATA, TEST RF 505-4B

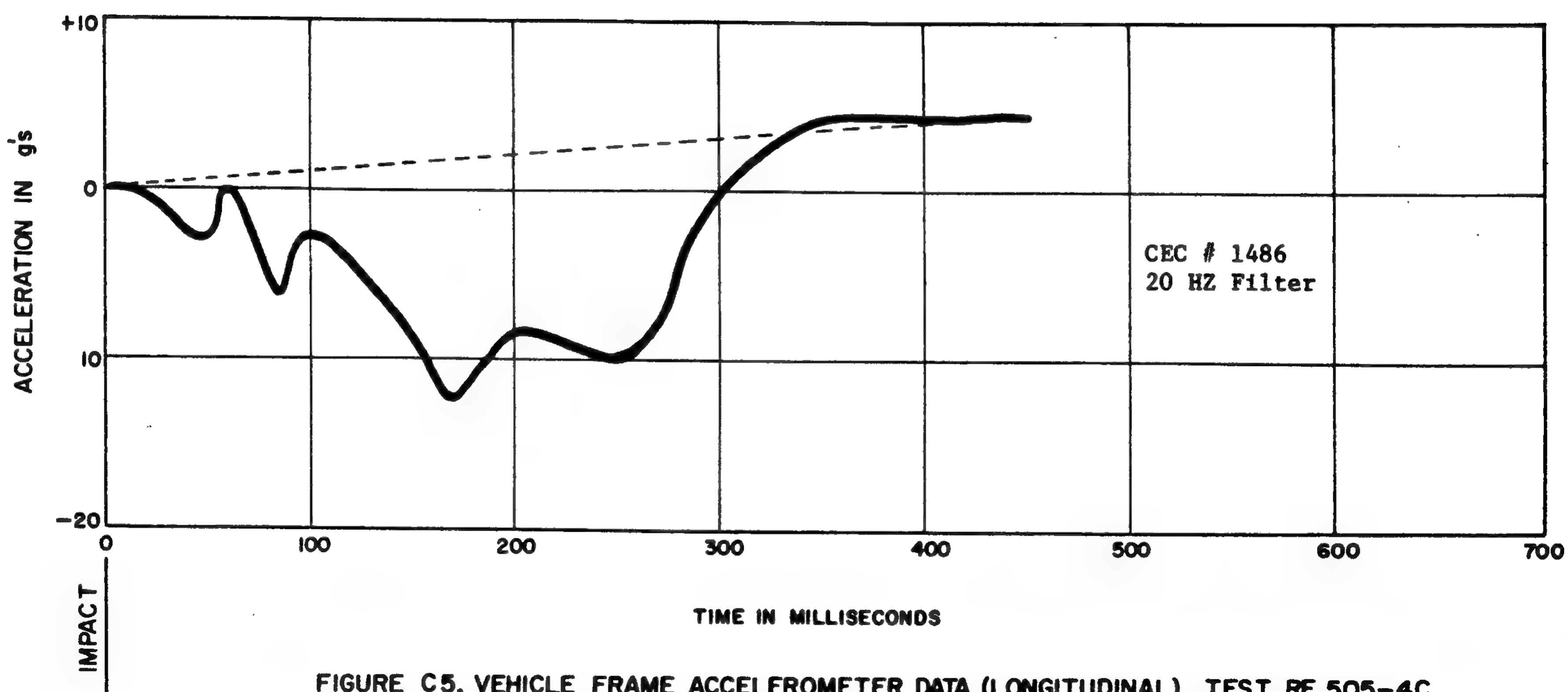



FIGURE C5, VEHICLE FRAME ACCELEROMETER DATA (LONGITUDINAL), TEST RF 505-4C

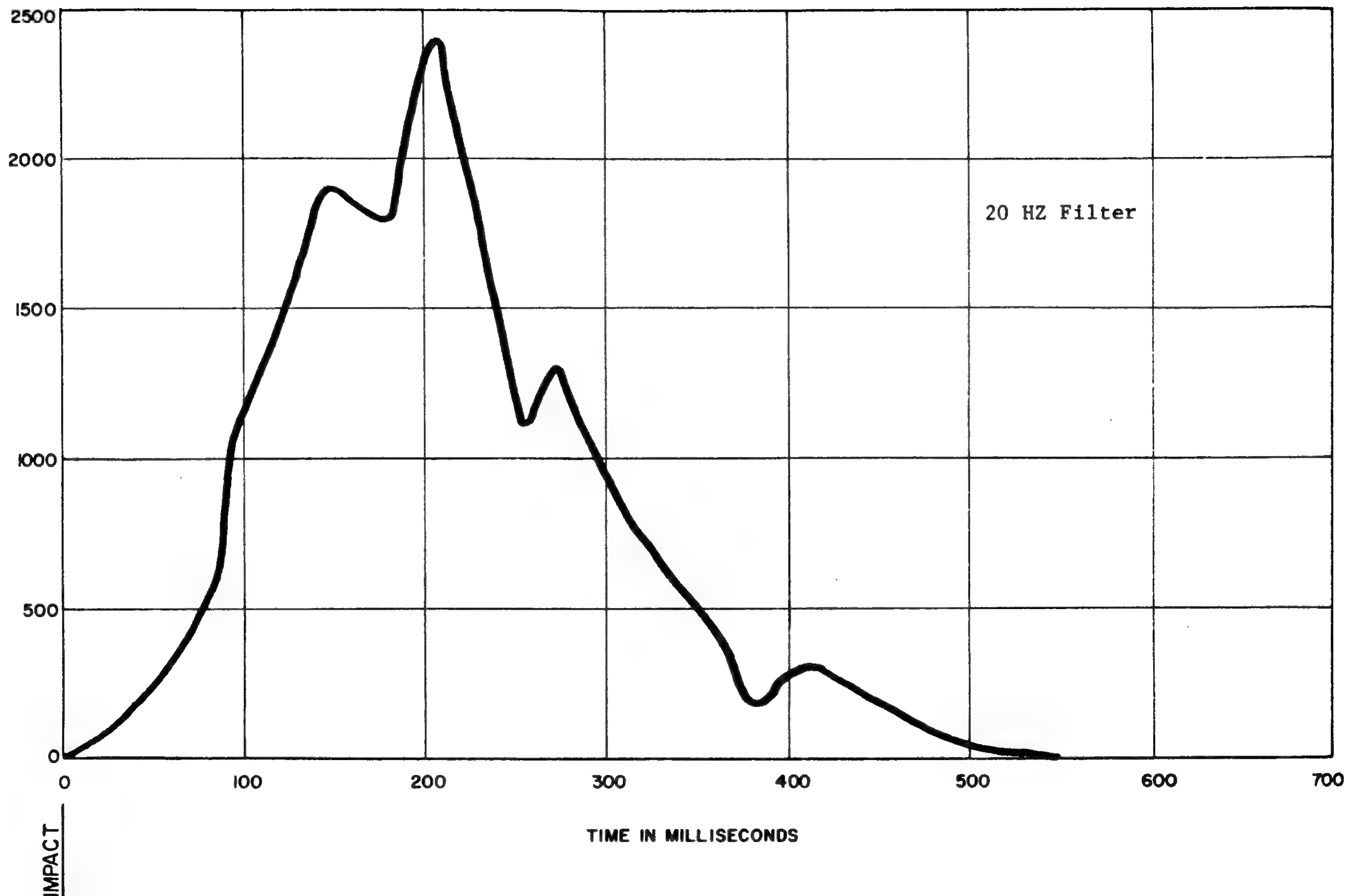



FIGURE C6, DUMMY SEATBELT FORCE DATA, TEST RF 505-4C

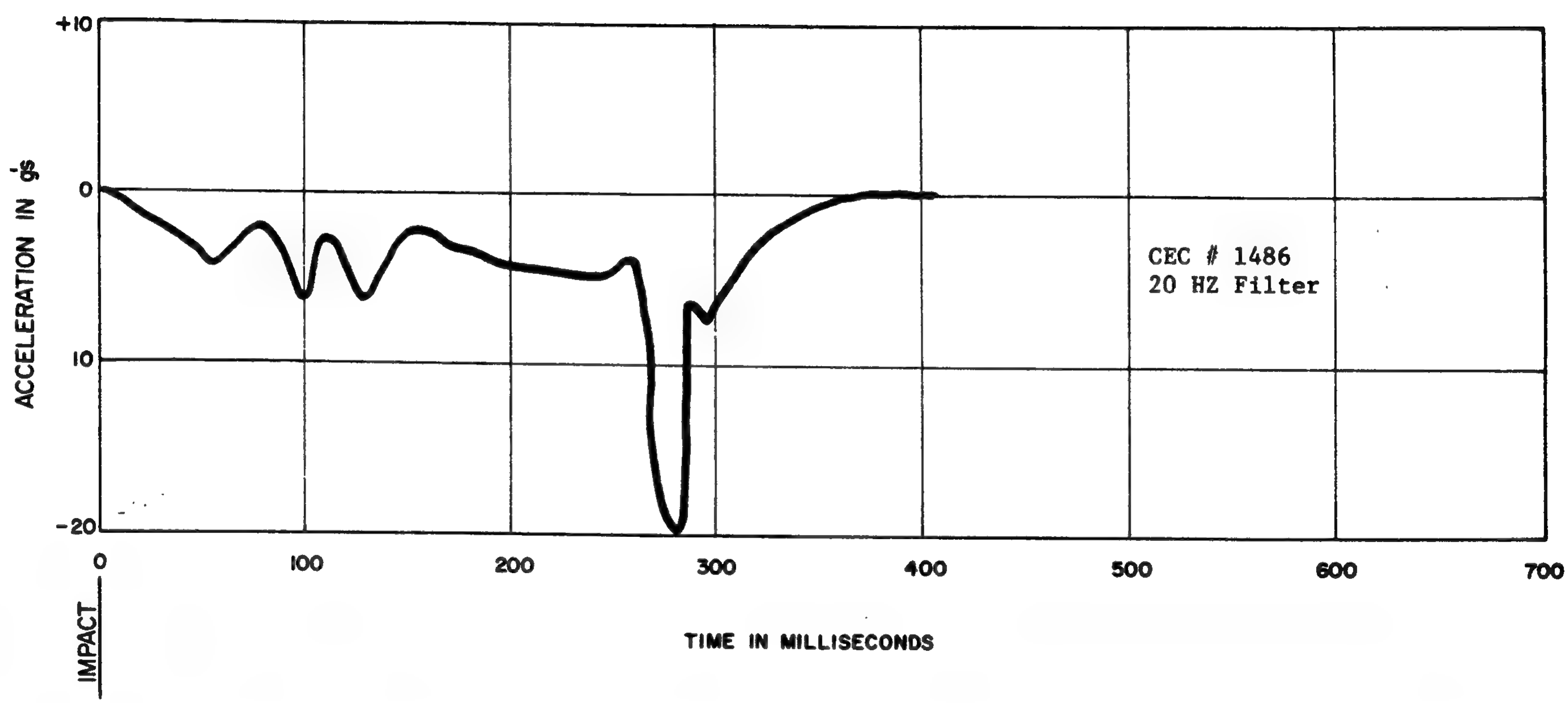



FIGURE C7, VEHICLE FRAME ACCELEROMETER DATA (LONGITUDINAL), TEST RF 505-4D

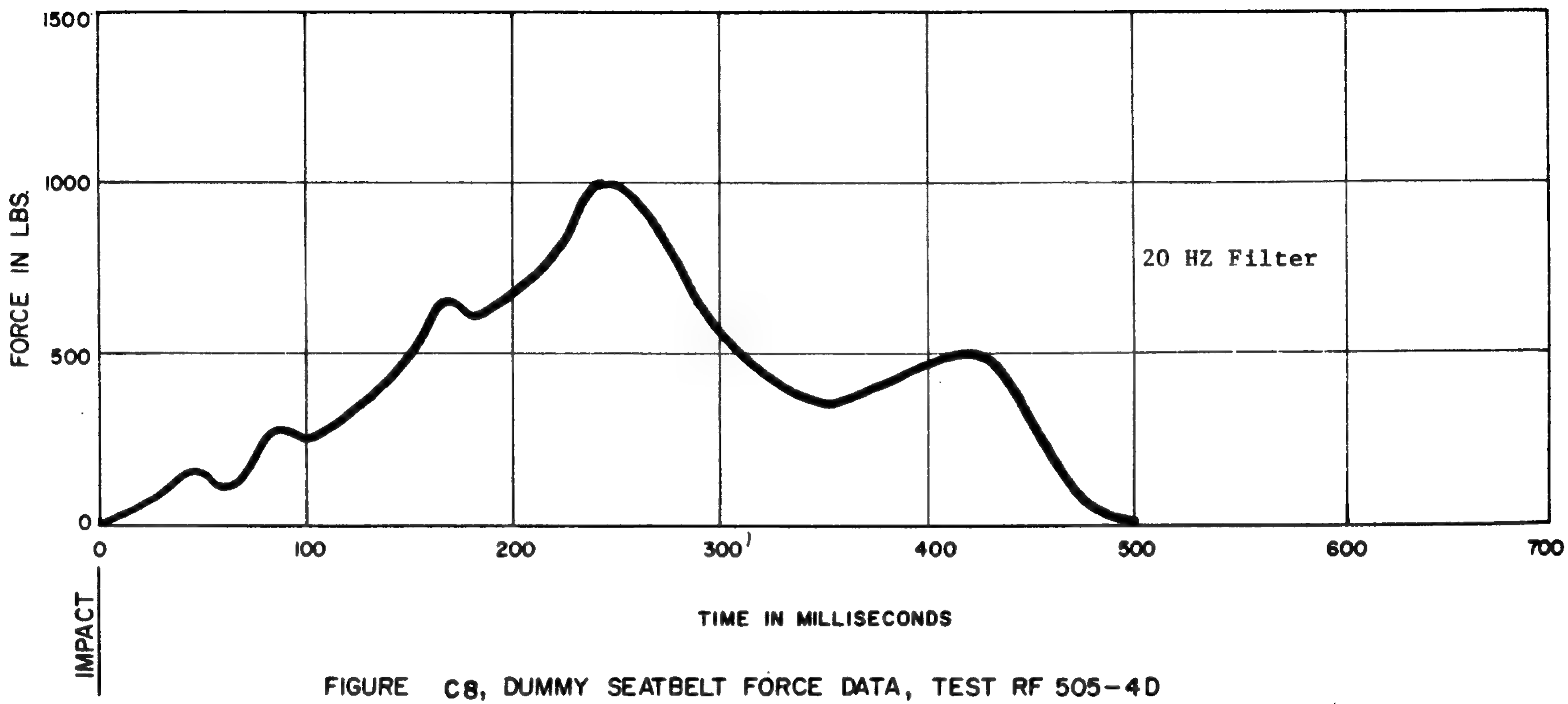



FIGURE C8, DUMMY SEATBELT FORCE DATA, TEST RF 505-4D

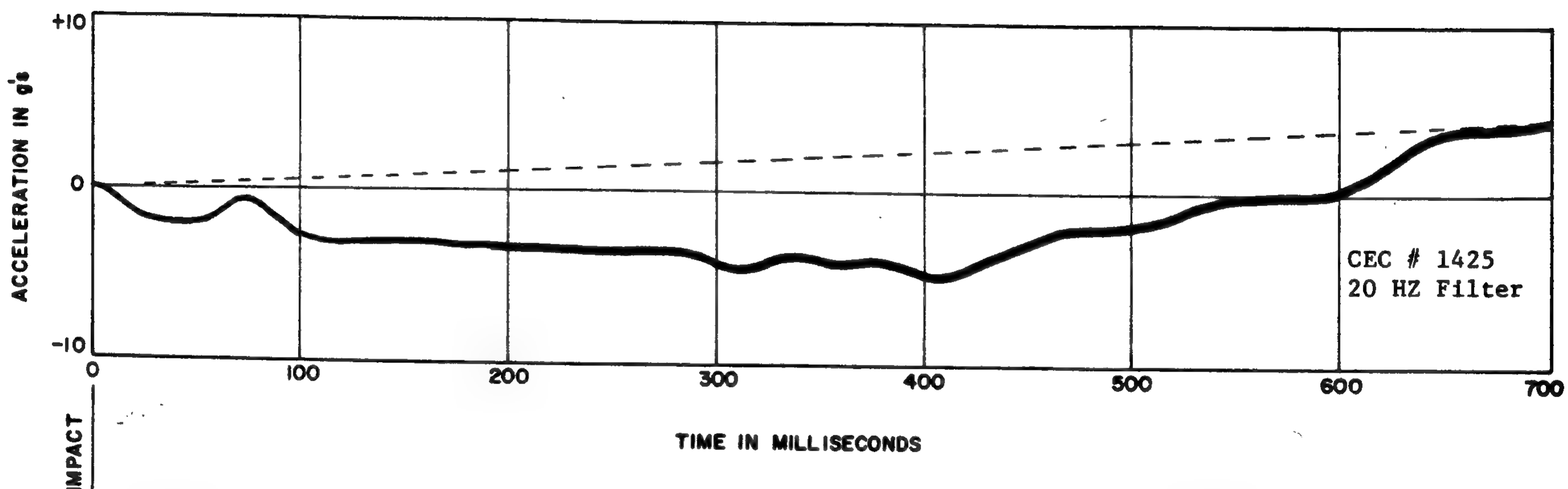



FIGURE C9, VEHICLE FRAME ACCELEROMETER DATA (LONGITUDINAL), TEST RF 505-4E

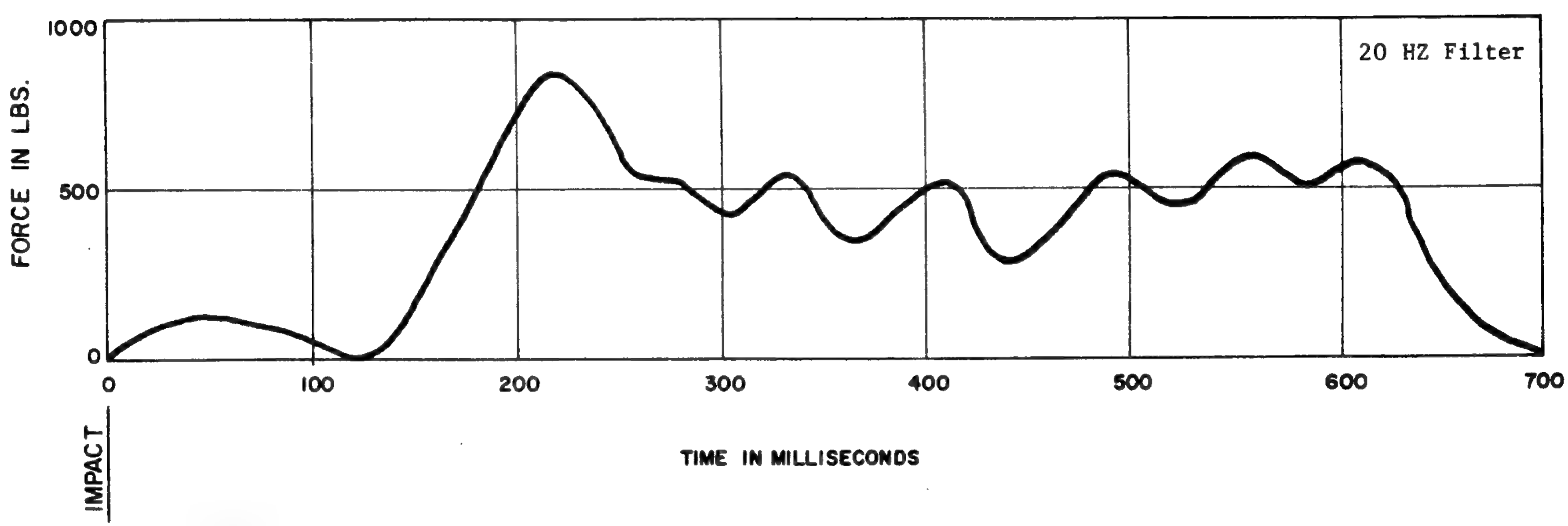



FIGURE C 10, DUMMY SEATBELT FORCE DATA, TEST RF 505-4E

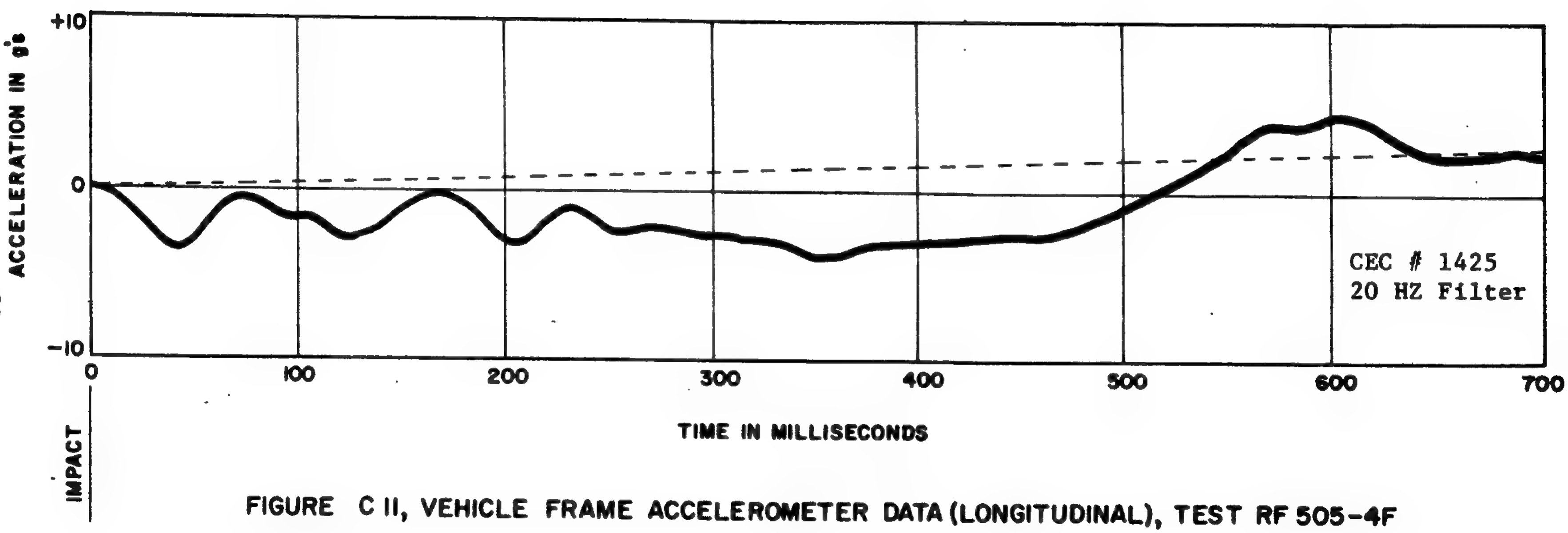



FIGURE C II, VEHICLE FRAME ACCELEROMETER DATA (LONGITUDINAL), TEST RF 505-4F

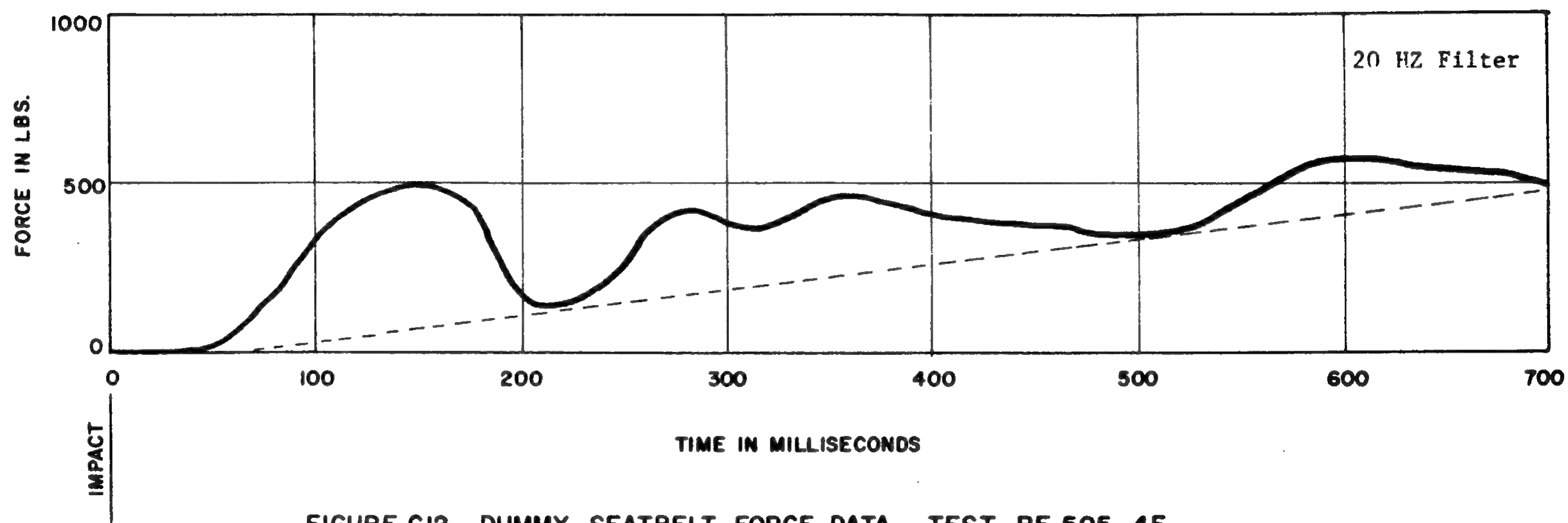



FIGURE C12, DUMMY SEATBELT FORCE DATA , TEST RF 505-4F



000625

VEHICLE ACCESS CONTROL AND SEARCH

Presented at a symposium on "Securing Installations Against Car-Bomb Attack"

Sponsored by the Defense Research Institute, Inc., 119 South St. Asaph Street, Alexandria, VA at the Sheraton National Hotel, Arlington, VA on May 17, 1986

PRESENTED BY

James E. Obermiller, LTC USAF (Ret)
Mason & Hanger-Silas Mason Co., Inc.

OPENING STATEMENT:

Thank you Mr. Solomonson for your kind introduction. Let me also add a note of appreciation that I would be invited and have the privilege of addressing this symposium, certainly representing a number of people who are quite knowledgeable and concerned with the subject at hand.

IDENTIFICATION:

By way of further personal identification, I should tell you that during twenty-five years with Mason & Hanger-Silas Mason Co., Inc., I have had the opportunity to work under a number of government contract operations which include, or are exclusively devoted to, the provisioning of Protective Force Security Services for the Department of Energy, the Department of the Army, the Los Alamos National Laboratory and the National Aeronautics and Space Administration at the Lyndon B. Johnson Space Center. Additionally, we have provided security design and study services to other agencies such as the Nuclear Regulatory Commission as well as to private clients.

BACKGROUND:

Mason & Hanger-Silas Mason Co. is pre-eminent in the field of explosives technology, particularly as it applies to explosive fabrication and the production of various items using both conventional and nuclear explosives such as bombs, artillery ammunition, detonators, primers, demolition blocks and other munitions of interest to the Department of Defense and the Department of Energy. Under this umbrella, I have been involved at length in the operations of security forces for the protection of these materials. It was on the basis of this experience that in 1979 Mason & Hanger was contacted by the Nuclear Regulatory Commission and asked to conduct some studies on methods by which vehicles could be searched and protective force officers could be taught the techniques of vehicle search. This was related to the

NRC's concern with the elements of sabotage of nuclear power plants or, alternatively, the theft or diversion of special nuclear materials. The result of this inquiry was, primarily, two study documents prepared for the NRC which were entitled "Vehicle Access and Control Planning Document" and the second, a "Vehicle Access and Search Training Manual". In this undertaking I was ably assisted by Mr. H. Joe Wait of my Company who had similar experience in our Department of Energy operations.

After these three days I am certainly aware of the many engineering and design approaches proposed to protect installations from car bomb attacks. With no intent to degrade or detract from the presentations that have been made, the emphasis here has largely been on approaches to "hardening" structures to withstand or resist an attack, or obstacles designed to impede immediate access through a control point with a resultant damage possibility. Certainly damage from rockets, small arms, or propelled explosive devices as well as an airborne assault can be well addressed from a design engineering point of view. However, assured success, or even limited success, from a terrorist point of view cannot always be completely achieved by these methods.

It should therefore be acknowledged that a favored approach to achieving a positive result on the part of a terrorist could well begin with subterfuge or surreptitious entry through an access control point, allowing closer proximity to a target. This also would allow an adversary to be very selective of his target and to exercise a sabotage or hostage threat. This can effectively be accomplished if the access control point can be breached. Therefore, the "soft point", if it may be termed as such, may be a favored combination of a man and a vehicle. The man (that is an adversary or terrorist) with his intelligence, has the advantage of flexibility in reacting to unforeseen situations. Coupled with this is the added advantage of cover and protection for his nefarious scheme in the nature of a vehicle of some sort. With these two elements in mind we should then address the possibility that an excellent chance of success would be the breaching of a vehicle or personnel access control point, getting inside the protected perimeter and close to a selected target.

VEHICLE THREATS

Vehicle threats may occur in several areas:

(1) The threat may occur on adjacent or nearby private or public property because we do not have complete control over vehicles in this area. Vehicles may have been "rigged", tampered with; have weapons, explosives or personnel concealed by built-in features or modifications for subsequent entry to the installation. Such vehicles might only be identifiable by their markings such as "UPS" or "Tom's Vending Service", for example or could even be private

automobiles previously authorized for access. Any vehicle which appears in this area without positive control is potentially a suspect vehicle.

(2) Controlled Area - The perimeter of a Controlled Area is the second "line" of concern. If control consists only of a barbed wire fence, or no fence at all, and if the perimeter is not lighted, alarmed or patrolled, the Area is readily accessible to an adversary vehicle. Vehicles in the Controlled Area (in a parking lot, for example) which are not under surveillance are subject to being tampered with. Therefore, any such vehicle in this area is also potentially a suspect vehicle.

Parking spaces in the Controlled Area are frequently designated for a particular employee, a mail vehicle, the site manager, security vehicles, and others. Such designations may identify specific vehicles which have access to a Protected Area or a particular person who could become a candidate for hostage. Such practices pinpoint potential targets for terrorists.

(3) Protected Area - Vehicles which have access to an internal Protected Area pose a threat in that they may be used to force entry through a wall, fence, door or gate.

Positive vehicle access and control should be established at the entrance to the Protected Area with a search for explosives, incendiaries, unauthorized personnel and weapons. However, due to the nature of these items, it is impossible to assure a statistically high confidence factor for discovery of all of these. Any vehicle which has been outside of the Protected Area without positive surveillance and control should be completely suspect prior to entering and <u>still</u> suspect after searching and access is authorized.

Ideally, the very <u>approach</u> of a vehicle toward the protected perimeter should be treated as a potential threat. Upon arrival at an access control point, the vehicle should be "trapped", sidetracked and isolated from the access point with the operator and/or passengers physically separated from the vehicle, and a detailed search accomplished.

EXPERIENCE AND OBSERVATIONS:

Our observations are that the key to effective control of vehicle entry and the reduction of the possibility of an adversary breaching the perimeter relies almost entirely on the performance of security officers attending the access control points. Often, we have relied on the simple presence and appearance of a uniformed individual. This may provide an "image" of security but is often deceiving. The individual may be uniformed, he may appear to be armed and able, but in fact may be restricted by policies or procedures which reduce his effectiveness. In fact,

the security officer may be prohibited from interference with visiting persons lest he incur the disfavor of the general public, scientists, VIP's, etc.

Secondly, the security officers' duties as he perceives them may certainly be different than what we desire. His efforts may be primarily directed toward badge checks, furnishing directions to visitors, control of traffic, fixed and scheduled tours to include turning off lights and coffee pots and punching clocks. This is not always a fault of the officer but rather a preference of his employer.

Thirdly, the security officer may be required to concentrate on routine, performing the same duties, the same activities in the same sequence.

Fourth, frequently we do not want to be inconvenienced. Specifically, as directly related to vehicle control, access and search, rudimentary observation is often considered sufficient. Often we are satisfied with the appearance of a search - a perfunctory exercise which might involve opening a briefcase, handbag or lunch container; raising the trunk of an automobile and "peeking" inside the vehicle. Occasionally this is related to the desirability to avoid personal contact, fearing complaint at the least and litigation in the extreme. Minimal searches are most likely to offend only those who are not really suspect. Good security checks are impediments which are considered intolerant, with a resulting degradation in security and the effectiveness of the security officer.

Lastly, the officer may have marginal qualifications. His experience may be limited. In many cases he is recipient of a minimum wage. Physical condition may be limiting his ability and in many, many cases his training is minimal or marginal at best.

We are forced to address the probability that automobiles, special equipment vehicles, truck-trailer transport units, construction equipment and railroad rolling stock are certainly a very real threat potential. Perfunctory sorts of searches as mentioned previously are unlikely to discern a dedicated threat.

SOPHISTICATED ATTEMPTS:

There are many materials and devices which would be useful in a sabotage or terrorist attempt and yet may be quite obvious. Many lethal and non-lethal items are "weapons of opportunity". "Weapons" may include a piece of pipe, board, wrench, chemicals, short sticks or other common and apparently "innocent" items. Devices in this category include clubs, knives, electric cattle prods, brass knuckles and aerosol or cartridge tear gas devices. Personal items, souvenirs and household utensils may be overlooked unless recognized for their potential as threat mediums. Household products in aerosol pressure cans (hairspray, lubricants, furniture polish) readily become flamethrowers by simply

igniting the spray. Folding book matches may be used as a fuse. Auto fuel certainly has an incendiary potential. Personal attirement of individuals with knives concealed in belt buckles is a possibility. Simple tools carried in a vehicle (hammers, pry bars, screwdrivers) can be used as offensive weapons in a vehicle threat attempt. Rescue vehicles such as ambulances and fire trucks normally have standard equipment such as axes, hatchets, containers, bottles, fire extinguishers and other items capable of concealing explosives or incendiaries. In maintenance vehicles we frequently see cable cutters, cutting torches and tool kits, all of which should be suspect items. Construction equipment which may pass through vehicle control points have power sources suitable for dragging, breaching and lifting. In commercial delivery vehicles, the content often is impossible to discern without a detailed search - boxes are sealed and the density of loads sometimes defies anything but minute examination. The complexity of machinery will disguise various devices.

Current technology makes the entire situation more complex. Today the use and application of plastic explosives is well known and recently, we are learning of pistols made of plastic. These are extremely difficult to identify unless the individual searching for these has been sufficiently trained in the detection and recognition process. Concealed explosives are a possibility if disguised as false parts. For example, sun visors may be fabricated of plastic explosives; gear shift knobs which may be quickly detachable might contain as much as a half to 1 pound of an explosive which could be used offensively.

The key then is the ability to discern and recognize articles, materials, explosives, and devices which might be used on an offensive basis. This then concerns three significant factors: 1) The security officer must be inherently suspicious; 2) He must be familiar with and drilled to recognize concealed materials and devices which could be used offensively; 3) He must certainly be dedicated to the vehicle search process and the discovery of any such material.

VISUAL AID #1:

Let me illustrate this in a little greater detail. On this chart we have a picture of a typical tractor trailer unit. In the left hand column we have indicated suspect areas of the vehicle. The vehicle component is indicated as to whether it is removable or fixed. The right hand column indicates the pounds of high explosive, which could be concealed therein. Note, for example, item number one which indicates a false air cleaner conceivably could contain as much as thirty pounds of high explosive. Item ten indicates an automobile glove compartment which could contain parcels or firearms and has the capacity to conceal perhaps twenty pounds of high explosive. Sun visors (line 16) are removable and have a weight equivalent of perhaps six pounds of high explosive. Note that line seventeen indicates that a spare tire can contain up to 100 pounds or more of high explosives.

This table, which is included in the NRC document identified as NUREG/CR-0485 "Vehicle Access and Search Training Manual" provides several indications of the potential of damage from various sources.

VISUAL AID #2:

BASIC SEARCH PROCEDURES:

In this visual, we are indicating six search patterns that are frequently utilized.

Pattern number one simply involves the security officer looking into the cab of the vehicle. Obviously this is largely nonproductive.

Pattern two is a slight improvement. The officer looks in the cab and in the trailer bed.

In pattern number three, a more comprehensive search is done, but still only provides an appearance of search. This includes the cab, the trailer bed, a look under the hood and a basic walk-around of the vehicle.

Pattern number four is a distinct improvement as it makes use of two persons. In this situation one officer concentrates attention on the vehicle while the attention of the driver is occupied by the second officer.

Further improvements are indicated in patterns five and six, which are successively more comprehensive and, necessarily, more time consuming. All of these are in the category of a perfunctory search. They certainly are not ones that can be expected to discover a cleverly concealed contraband device.

IMPROVED SEARCH PROCEDURES:

We have developed a suggested procedure in which four levels of search, in various degrees of complexity, will enhance the possibility of discovery of threat materials. These searches can be supported with both simple and technical devices such as explosive detectors, rolling mirrors wheeled under the vehicle and flashlights for example.

VISUAL AID #3:

The Four Search Levels are described here: Some Procedural data was derived from material published by the National Bomb Data Center.

Level 1 Search. This includes general examination of a vehicle's main compartments (engine, trunk, cargo, passenger, cab, undercarriage, etc.) and may be supported with the use of explosive detectors, remembering that these may only be 25 to 50 percent

effective dependent on the person conducting the search, the time allowed and the instrument used. Failure of the vehicle to pass this search should result in certain alternatives (access denial, arrest, Level 2, 3, or 4 searches, or impoundment as appropriate). Search time under this condition with a trained security officer approximates 5 to 10 minutes.

Level 2 Search. This is a thorough and deliberate search of all parts of a vehicle which are visually accessible and accessible by design (opening trunks, tire, engine, and cargo compartments, glove compartments, etc.). This search should be conducted with mirrors, flashlights, flex-scopes, etc., as required to assure coverage. This search may also be supported with the use of an explosive detector. A Level 2 search will occupy time on the order of 15 to 20 minutes.

Level 3 Search. This search level includes the Level 2 search plus non-destructive disassembly of the vehicle. There should be specific justification for the search to progress this far (suspicious activities of the vehicle driver and/or passenger, or positive explosive detector indications for example). Disassembly might include removal of hubcaps, air cleaners, head and tail light lenses, panels, etc., which can be accomplished without damage to the vehicle. It is also possible that this may be carried out utilizing non-destructive x-ray techniques. Search should be specifically authorized by a designated security official.

Level 4 Search. This search level includes the previous Level 1-3 techniques plus destructive disassembly. It conceivably would include cutting into upholstery, disassembly of oil filters, removal of tires, etc. If a Level 4 search is indicated, access of the vehicle would be denied, and the probability of recompense to the owner acknowledged.

Search times for Levels 3 or 4 may require upwards of one hour dependent on the vehicle and its components.

NOTE: If a vehicle is suspected of harboring any explosives, extreme caution should be exercised and the vehicle denied access pending examination by trained bomb search personnel.

VISUAL AID #4: (Address the pictures)

Level 1 Search - Automobiles

VISUAL AID #5
Level 1 Search - Trucks

VISUAL AID #6
Level 1 Search - Special Equipment

VISUAL AID #7
Level 1 Search - Railroad Rolling Stock

VISUAL AID #8
Level 2 Automobile Search (20 check points)

VISUAL AID #9
Level 2 Searches (Trucks & Rail Cars) - 22 check points

VISUAL AID #10
Level 2 Auto Search (Structural) - 54 check points

Certainly the most obvious thing here is that the control of vehicles passing a check point and a thorough search of a vehicle requires an extended amount of time. Although involving added expense, it improves the image and effectiveness of the security force manning the check point and should discourage the probability of introduction of concealed contraband or explosives through the check point.

Finally, we should briefly address the subject of animal-assisted searches and the use of mechanical devices. Animals, particularly canines certainly are an important adjunct to a comprehensive and productive search. Dogs, by their nature, may be intimidating to people and they are effective in discovery of explosives. Information available from certain sources and visits to some facilities indicates that other animals are perhaps even better adapted to the search for explosives. One of these species are swine although admittedly, pigs are probably socially unacceptable. In terms of devices, X-ray, metal detectors or explosive detectors may render assistance although some technical expertise and training is essential. Some problems here continue to occur however due to false alarms or false reading. Mechanical devices presently in existance, and known to me, should not be trusted solely on their own merit.

SUMMARY:

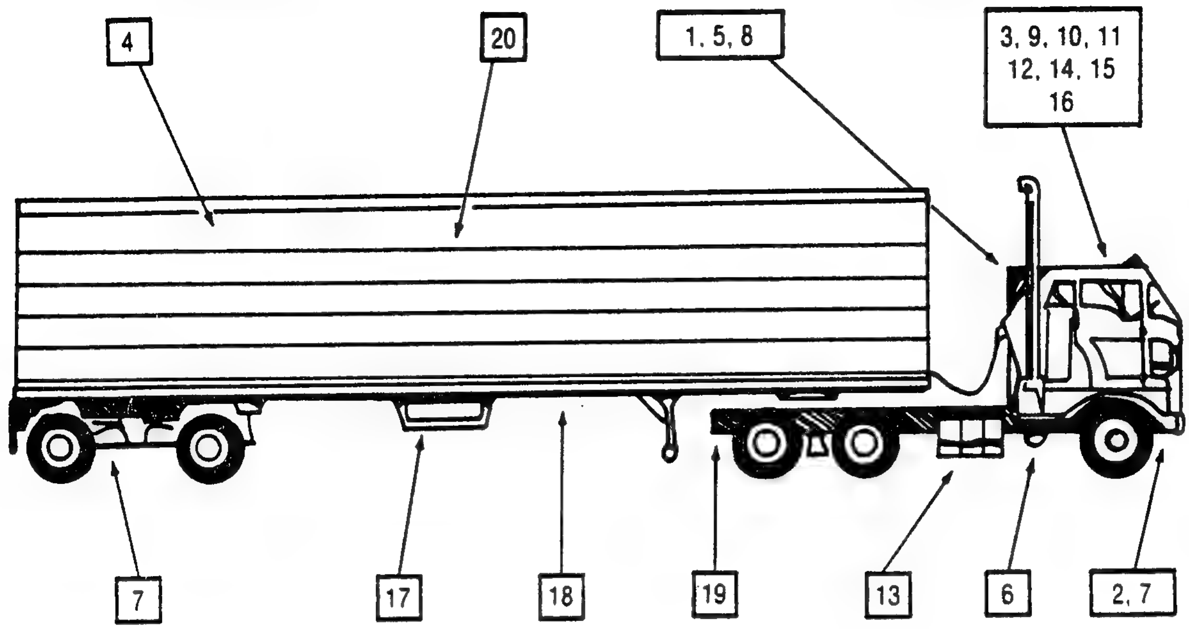
Finally, we should make some overall observations which are appropriate. We have long passed the days when a watchman or bank guard type of individual is the person we need in our protective forces. We need people who have mature judgement, are inquisitive, trained, physically agile, of perhaps unusual intelligence, dedicated to the task and well paid for their services. They must, in truth, be professionals. Without these attributes and rewards, the task of effective vehicle access and control will largely be non-productive.

FINISH:

This has certainly been only a highlight description of our efforts in the research of possibilities relative to vehicle control and access related to car-bomb attack. Limited by time, I may then only say that I would advise an extended reading of the two documents previously mentioned and identified in the earlier portion of my presentation.

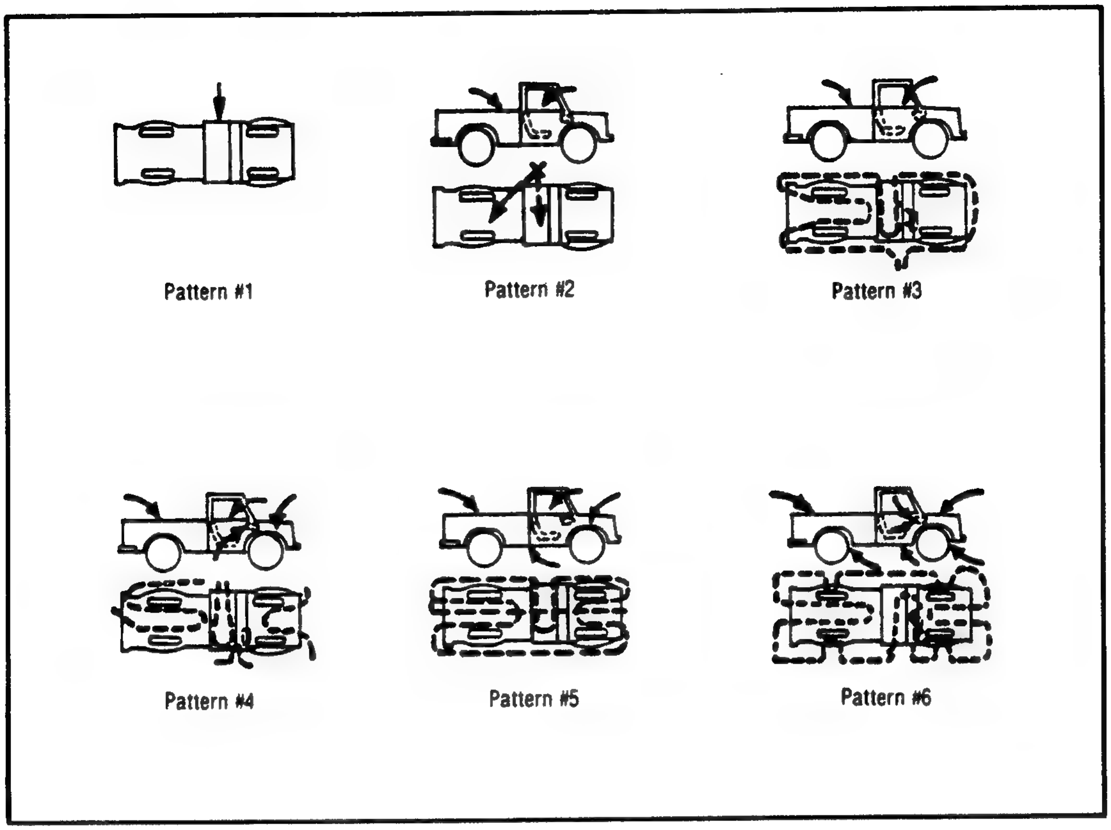
Thank you for your attention.

## POTENTIAL FOR CONCEALING PROHIBITED ARTICLES IN VEHICLES




| No. | Suspect Area | Portability | | Concealment Potential | | | | |
|---|---|---|---|---|---|---|---|---|
| | Area or Component | Remov-able | Fixed | Parcels | Firearms | Personnel | SNM | High Explo-sives lbs. |
| 1 | Air cleaner (false) | x | | x | | | x | 30 |
| 2 | Bumpers | | x | x | x | | x | 20 |
| 3 | Tractor body panels | | x | x | x | | x | 20 |
| 4 | Trailer body panels | | x | x | x | | x | 100's |
| 5 | Battery | x | | x | x | | x | 50 |
| 6 | Air tank | | x | (explosives) | | | x | 100 |
| 7 | Fender wells | | x | x | x | | x | 40 |
| 8 | Engine compartment | | x | x | x | | x | 100 |
| 9 | Door panels | | x | x | x | | x | 20 |
| 10 | Glove box | | x | x | x | | x | 20 |
| 11 | Headliner | | x | x | x | | x | 20 |
| 12 | Under dash | | x | x | x | | x | 50 |
| 13 | Fuel tanks | | x | | | | x | 700 |
| 14 | Under seats | | x | x | x | | x | 100 |
| 15 | Seats (upholstery) | | x | x | x | | x | 20 |
| 16 | Sun Visors | x | | x | x | | x | 6 |
| 17 | Spare tire | x | (explosives) | | | | x | 100+ |
| 18 | Trailer frame | | x | x | x | | x | 100 |
| 19 | Tractor frame | | x | x | x | | x | 50 |
| 20 | Cargo & area | x | x | x | x | x | x | (tons) |

## BASIC VEHICLE SEARCH PATTERNS




<u>**Search Pattern #1**</u>: Vehicle driver recognition.

<u>**Search Pattern #2**</u>: A physical/visual observation of the passenger area and cargo area.

<u>**Search Pattern #3**</u> A basic, but more comprehensive physical/visual search of the passenger area, interior compartments and cargo area.

<u>**Search Pattern #4**</u>: This is similar to Pattern #3 but includes minute details of under seat, under dash and glove compartment and a visual inspection of the undercarriage.

<u>**Search Pattern #5**</u>: Includes a visual search of the engine compartment, fender wells, cargo area, passenger area, under seats, under dashboard and glove compartment.

<u>**Search Pattern #6**</u>: a random vehicle area search, detailed in scope and avoiding "standard" fixed patterns which would be observed as routine.

<u>**NOTE**</u>: Search Patterns #4, 5 and 6 are best accomplished by a team of two persons, one keeping the vehicle operator under surveillance.

## SUGGESTED VEHICLE SEARCH LEVELS

**Level 1 Search.** This includes general examination of a vehicle's main compartments (engine, truck, cargo, passenger, cab, undercarriage, etc.) and may be supported with the use of an explosive detector. Failure of the vehicle to pass this search could result in certain alternatives (access denial, arrest, Level 2, 3, or 4 searches, or impoundment as appropriate).

**Level 2 Search.** A thorough and deliberate search of all parts of a vehicle which are visually accessible and accessible by design (opening trunks, tire compartments, engine, trunk, cargo compartments, glove compartments, etc.). This search should be conducted with mirrors, flashlights, flex-scopes, etc., as required to assure coverage. This search may also be supported with the use of an explosive detector.

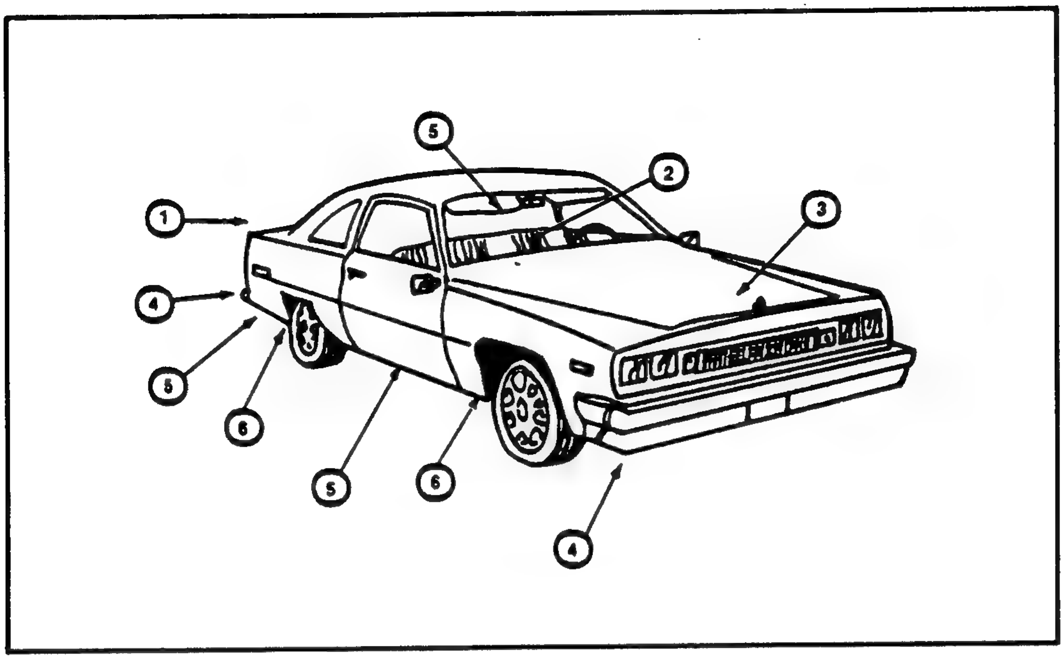
**Level 3 Search.** This search level includes the Level 2 search plus non-destructive disassembly of the vehicle. There should be specific justification for the search to progress this far (suspicous activities of the vehicle driver and/or passenger, or positive explosive detector indications for example). Disassembly might include removal of hubcaps, air cleaners, head and tail light lenses, panels, etc., which can be accomplished without damage to the vehicle. It is also possible that this may be carried out utilizing non-destructive x-ray techniques. Search could be authorized by the security supervisor.

**Level 4 Search.** This search level includes the previous Level 1-3 techniques plus destructive disassembly and might include cutting into upholstery, oil filters, tires, etc. If a Level 4 search is indicated, access of the vehicle should be denied.

**NOTE:** If a vehicle is suspected of harboring any explosives, external caution should be exercised and the vehicle denied access pending examination by trained bomb search personnel. Some procedural data derived from the National Bomb Data Center.

## SEARCH PROCEDURE

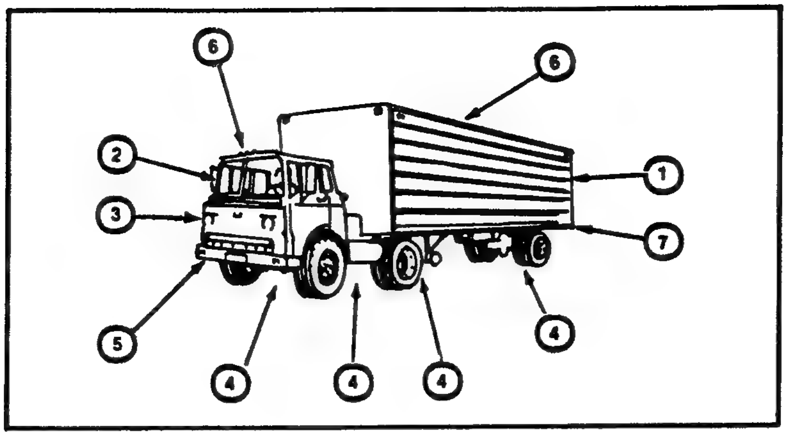
### Level 1 Physical/Hand Search—Automobile

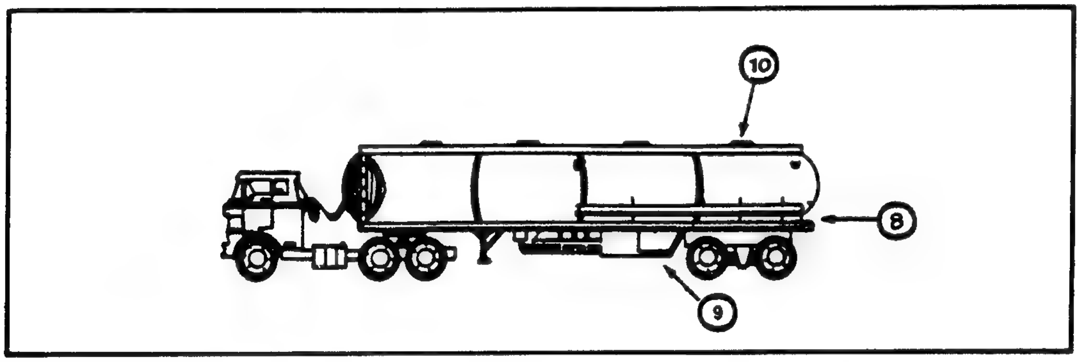



1. Trunk Compartment (including behind seat, storage, etc.)
   a. Luggage, parcels, packages
   b. Tool boxes
   c. Around spare tire
   d. All interior surfaces and voids
   e. Fuel cans and air cylinders (off load fuel cans and other incendiary materials)
2. Passenger Area
   a. Luggage parcels, packages
   b. Under dash
   c. Under seats (visible areas)
   d. Glove compartment and contents
3. Engine Compartment
   a. Underside of hood
   b. General fire wall, behind grill, and engine area (look for unnecessary components, type, etc.)
4. Inside bumpers (front and back)
5. General undercarriage and roof (check carefully around fuel tanks)
6. All (4) wheel wells.

## SEARCH PROCEDURE

### Level 1 Search—Trucks



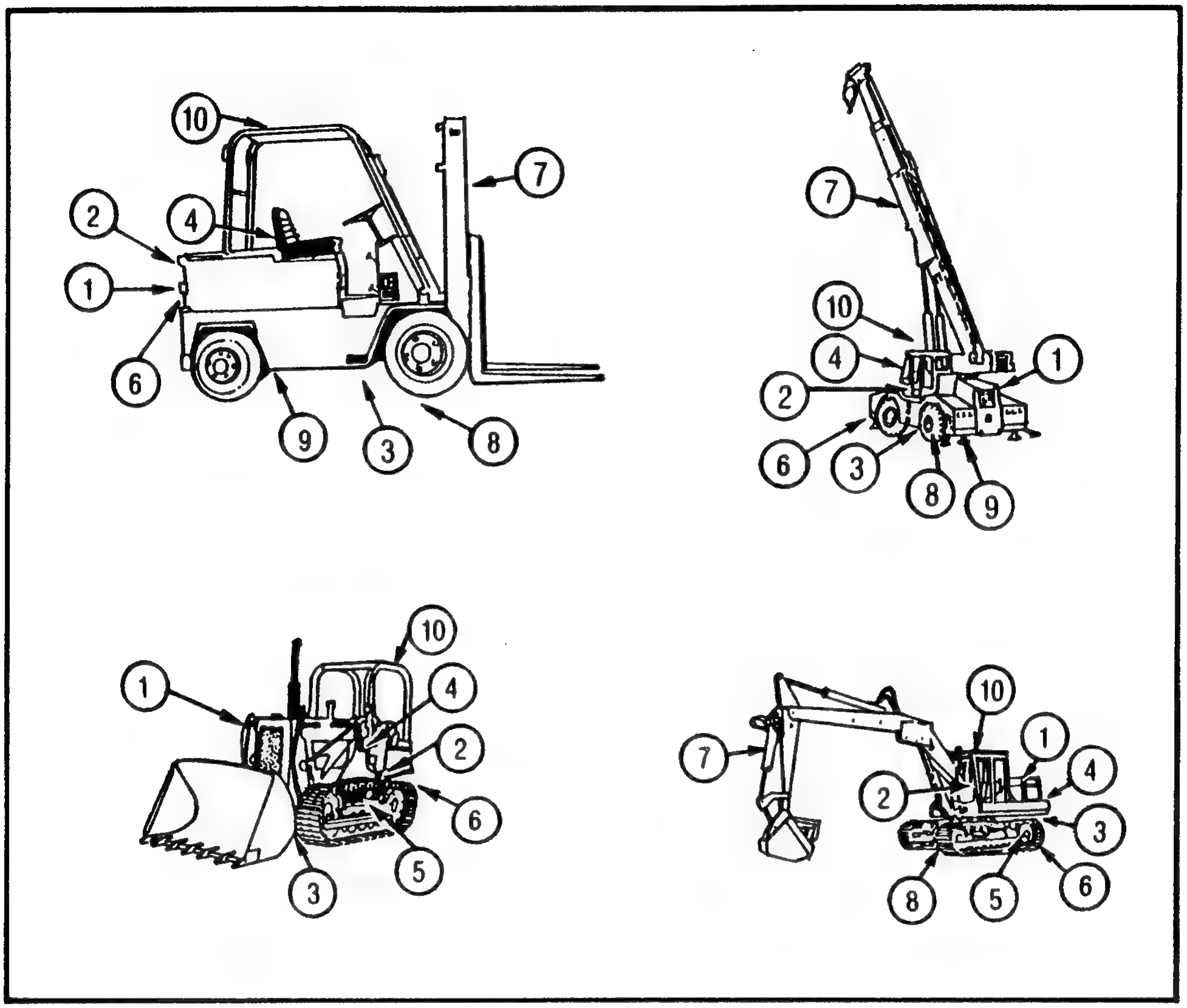

**Trucks (General)**

1. Cargo Area
   a. Parcel, package and equipment, etc. (see note)
   b. Ceiling, walls and floor (walk-thru)
   c. Non-cargo containers, tool boxes, etc. (off-load cans)
2. Passenger Area
   a. Parcels and packages
   b. Luggage
   c. Under seat and behind seat (fold up/down seats)
   d. Sleeper area
   e. Glove compartment and cab storage areas
3. Engine Compartment
   a. Open hood or cab cover. Search readily accessible areas.
4. General frame work, undercarriage and wheel assemblies, tool boxes, wheel wells, etc. (check around fuel tanks very carefully).
5. Bumpers, steps, and runningboards
6. Roof or cab and cargo box/trailer
7. Check external trailer compartment length, depth, etc., to assure that false panels capable of concealing personnel are not built in.

**Tank Trucks**

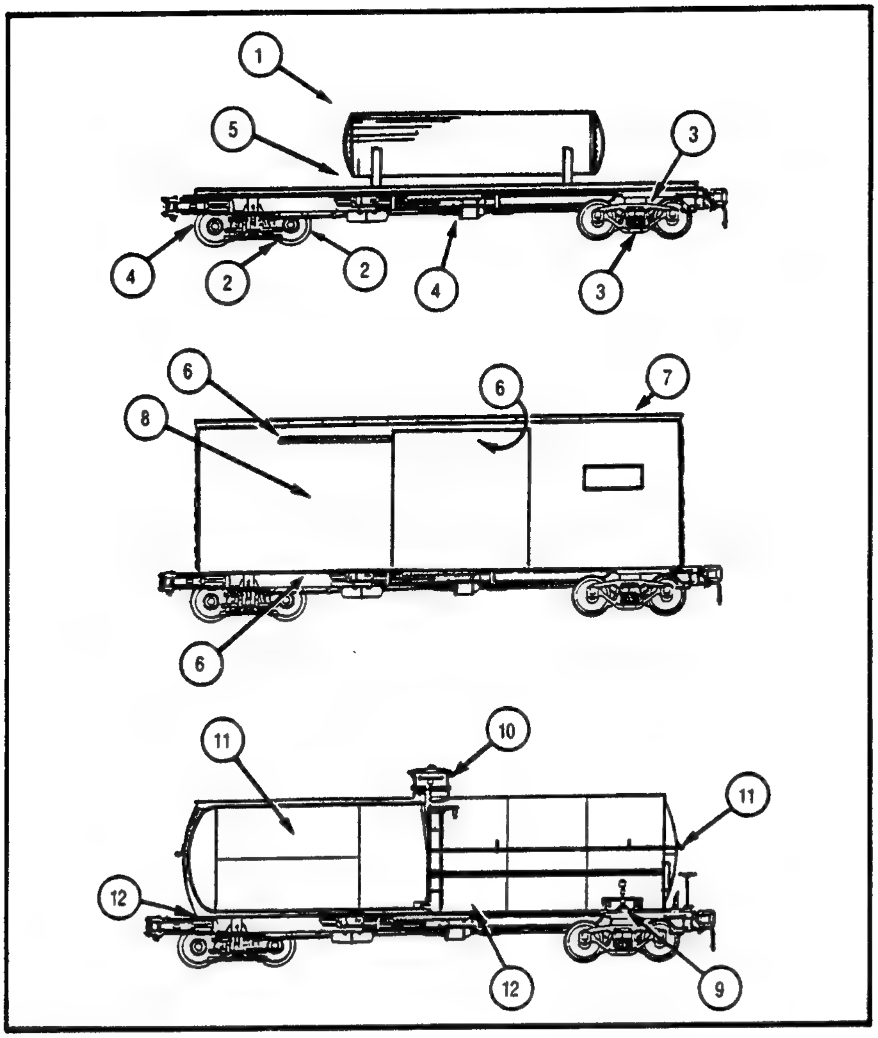
8. Check hose compartments.
9. Check pump compartments.
10. Check filler cap area.

**LEVEL 1**
**PHYSICAL/HAND SEARCH**
**SPECIAL EQUIPMENT**




1. Engine compartments
2. Storage and tool compartments
3. Undercarriage (all the way around)
4. Under seats and cushions
5. Behind track mechanisms
6. Battery compartments
7. Booms and masts
8. Behind wheels
9. Fender wells
10. Roofs

**LEVEL 1**
**PHYSICAL/HAND SEARCH**
**RAIL CARS**




**Non-Couriered Rail Shipments** (cars picked up or delivered)

1. Seals on casks, fuel assemblies, or special containers
2. Wheels (inside and outside)
3. Behind trucks
4. Undercarriage of bed. Search channel and "I" beams, side sills, floor supports and coupling shank.
5. Containers, dunnage, equipment, materials, etc.

**Box Car** (in addition to Non-Couriered Rail Shipment Search)

6. Interior walls, floor, ceiling, door
7. Roof and walkway
8. Exterior surface. Check any voids and access panels.

**Tank-Type Car** (inspect carefully and closely in addition to Non-Couriered Rail Shipment Search)

9. Hose lockers or pump mechanism panels
10. Fill port area and walkway
11. Surface of tank for unusual attachments
12. Channels and voids created where tank joins carriage or bed



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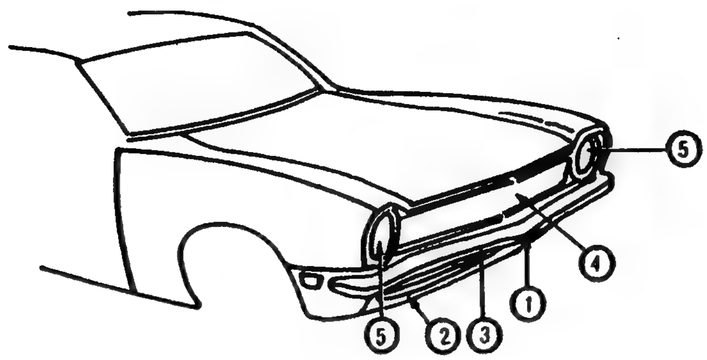
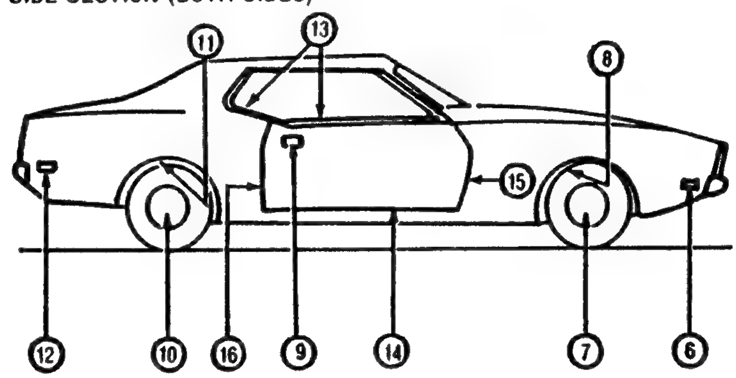
**LEVEL 2**
**PHYSICAL/HAND SEARCH**
**AUTOMOBILES**

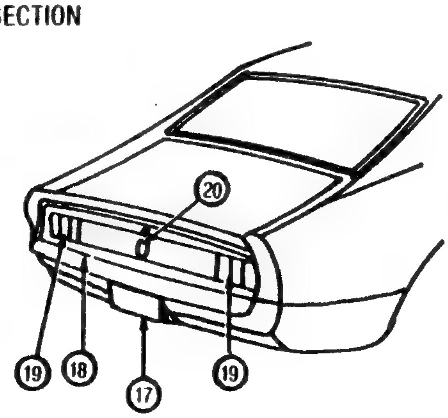
A-FRONT SECTION




B-SIDE SECTION (BOTH SIDES)




C-REAR SECTION



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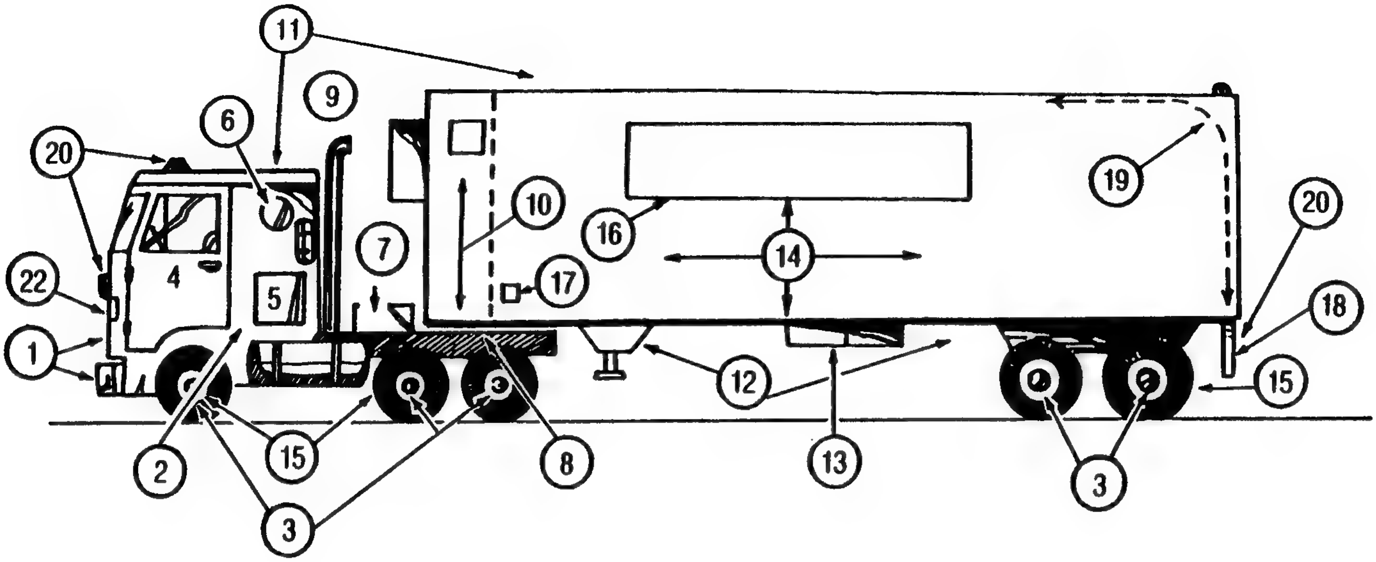
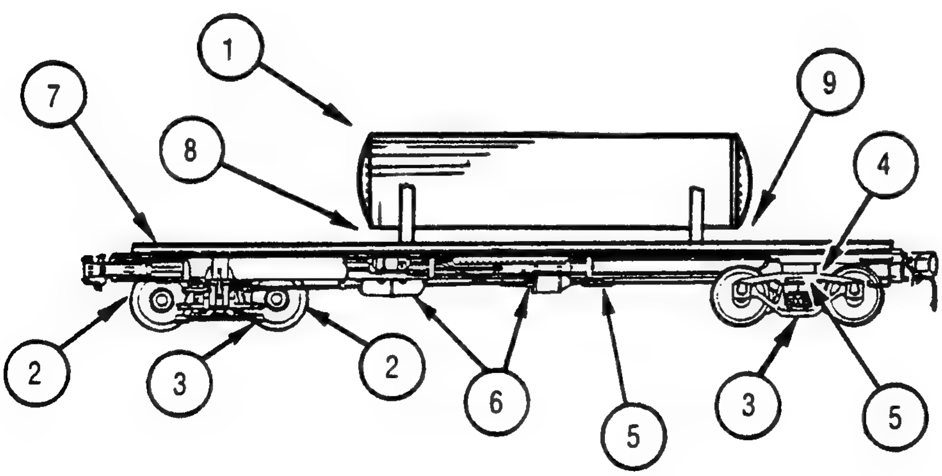
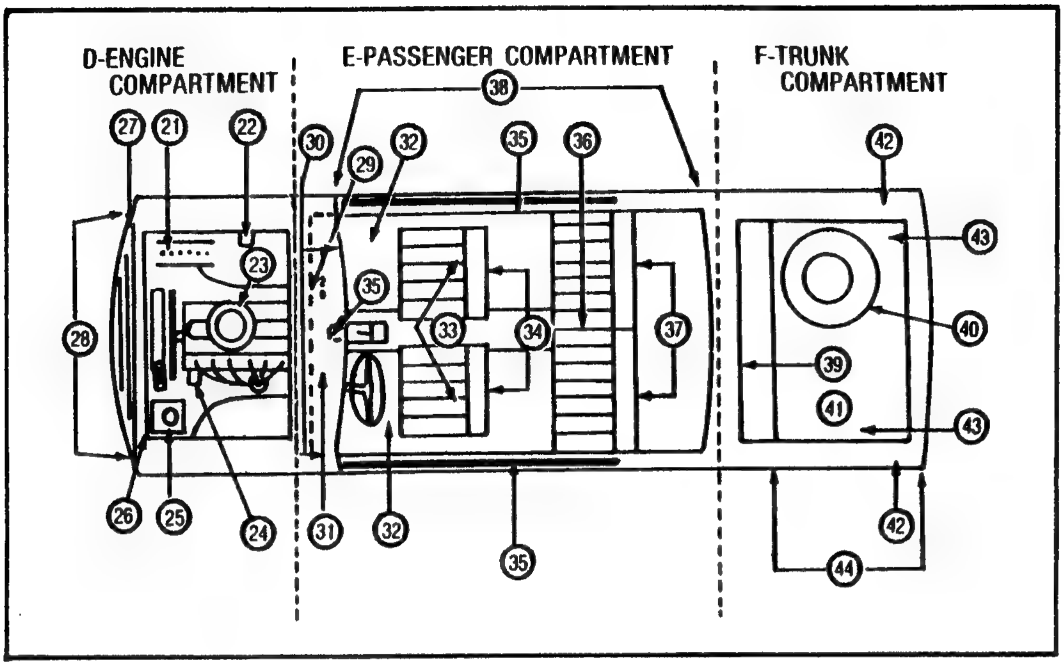
## LEVEL 2
## PHYSICAL/HAND SEARCH
## TRUCKS—GENERAL

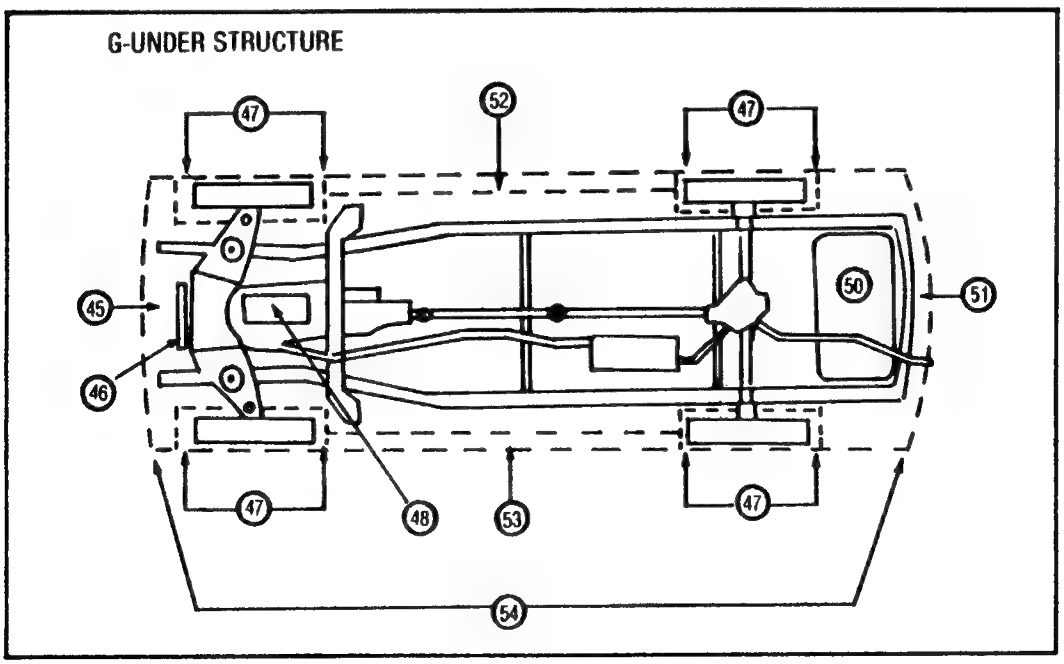



## LEVEL 2
## PHYSICAL/HAND SEARCH
## RAIL CARS



LEVEL 2
PHYSICAL/HAND SEARCH
VEHICLE STRUCTURAL COMPONENTS



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# SYSTEMS SECURITY ENGINEERING
# APPLIED TO THE CAR-BOMB THREAT

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Presented May 15, 1986 to the Washington, D.C. Conference on Securing Installations Against Car-Bomb Attack

# SYSTEMS SECURITY ENGINEERING - APPLIED TO THE CAR-BOMB THREAT

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This paper discusses the selection and utilization of security technology in the context of the overall security effort. Is is broken into two parts; first a review of some basic security concepts and, second, a recommended process to be used in applying security technology to car bomb and other threats in a fashion which is consistent with those basic concepts.

## SECURITY FUNDAMENTALS

### GOALS OF SECURITY

The primary goal of security is the protection of critical assets, key personnel and sensitive information. That goal must be realized in the face of both covert (surreptitious/deceptive) and overt attacks. While the probability of overt attack may arguably be low, the consequences are so catastrophic that they warrant substantial outlays for an all encompassing, integrated security program.

### THE THREAT

Although a balanced security program will address all types of attack, it is appropriate to identify the highest level of threat because countermeasures to that threat will also be useful in countering lower levels of threats.

In the worst case, the potential perpetrators are:

Well trained

Well equipped

Highly professional

Extremely motivated

The attack objectives of this top level threat are to:

Cripple the targets' ability to perform its basic mission,

Publicly demonstrate the facility's vulnerability,

Instill terror or confusion for political purposes.

## THE ADVERSARY'S ADVANTAGES

The attackers have a tremendous advantage over the defenders because they choose the target, the time, and the attack methodology. Well planned attacks are characterized by detailed intelligence gathering, initially by simple observation to determine procedures, patterns, potential pitfalls. Later, probes by deceptive or surreptitious means can be used to test the system in depth or explore what can't be seen readily. Despite almost fanatical dedication, these "crazies" aren't. They are clever, and usually interested in saving their own skin, so they will exploit the greatest vulnerability with the least risk. This intelligence phase usually determines the attack methodology which is often a hybrid-surreptitious or deceptive entry and penetration until discovery and then overt attack through to completion or capture. If there is a diversion, a preplanted explosive detonated remotely on discovery, or a preplanned civil disturbance to coincide with reaching an objective--so much the better.

## A COMPREHENSIVE SECURITY EFFORT

A comprehensive security effort consists of three parts:

1. Protective intelligence which involves the anticipation of attack and contingency planning.

2. A site specific security program, which involves protection of the facility and detection of an attack.

3. Crisis management involving the immediate response to an attack limiting the damage. Crisis management is essentially the management of surprise.

For best results, these three elements should be related using a systems approach or holistic perspective. Protective intelligence, the site specific security program, and crisis management are all interconnected and interactive. A comprehensive security effort must always be focused on the fact that security is an operational discipline.

## PROTECTIVE INTELLIGENCE

Local personnel must take the lead responsibility for protective intelligence. When they can obtain good assistance from senior commands and other agencies, such assistance is essentially generic while the real threat is always very specific.

There are four steps in an effective protection intelligence operation. They include:

1. Intelligence gathering/analysis efforts.

2. Scenario generation (anticipation).

3. Contingency planning.

4. Training and drilling.

Following up on the general threat intelligence information available, local personnel should focus on two issues:

- o What types of threats or attacks have been made against similar installations around the world? For example, if the facility being protected is a military airfield it is prudent to be knowledgeable about what sort of problems that have been experienced by military airfields regardless of location.

- o What types of threats or attacks have been made against other, not necessarily similar installations, in the particular country, state/province, region, neighborhood where the particular installation is located? In this case, while the facility to be protected may be a military airfield, attention should be given to attacks and threats against industrial facilities, power plants, etc. in the immediate vicinity because perpetrators and M.O.s tend to be similar.

## SITE SPECIFIC PHYSICAL SECURITY PROGRAM

A good site specific physical security program has several functions.

1. Deterrence
2. Delay
3. Detection
4. Alerting
5. Response
6. Neutralization

Deterrence can be viewed as the ultimate success of any security program. If a facility is so well protected the potential attackers decide the likelihood of success is so low that they select a different target, you have success. For this reason, in the security business, most of the successes or victories are unknown.

The delay function comes into play when an attack is launched. The process here involves the combination of barriers, locks, traffic flow systems and so forth which will slow up an attack and therefore give the protection force more time to respond.

The site specific physical security program should have the earliest possible detection capability so that as soon as possible after an attack is launched, the guard force can be brought into play. Again because of the very short amount of time needed by the attackers to have a major impact, early detection is essential.

The fourth function, alerting, involves communicating the nature of the attack and the location of the attack to the response force with a method which is both clear and quick.

The fifth function of a site specific physical security program is the response to interdict between adversary and resource.

Neutralization could imply a wide range of actions, but for our purposes it is simple control of the adversary so that he no longer poses an immediate threat.

All five of these functions must be carried out while allowing necessary personnel in the facility to work and move about with minimum interference.

## COMPONENTS OF A SECURITY PROGRAM

The site specific physical security program consists of four major elements. The effectiveness of the program depends upon the combination of these components. Relying on any one component to the exclusion of the others, defeats the benefit of the systems leverage which comes from multiple approaches to what is a systems challenge.

### Policies and Procedures

The formalized ways various security functions are carried out constitutes the glue which holds the entire security effort together.

- Security program plans
- Intelligence and threat analyses
- Instructions and manuals
- Standards of performance
- Criteria for facilities and systems

### Personnel

The key element of the site specific physical security program is a team of human beings who are well trained, well equipped, and highly motivated. They must be knowledgeable about their potential adversaries and most importantly, able to respond effectively to surprises.

- Recruitment and selection
- Utilization
- Training
- Support

### Facilities

The hardened or reinforced structures or obstacles and the designated entry and exit points of a facility are in themselves key elements of the security "system".

- Vaults, entry points, secure rooms
- Response force facilities
- Barriers
- Structures designed to withstand ballistic attacks

Systems and Equipment Component

Security technology is employed primarily to enhance the capability of the human guard force. It allows for more comprehensive coverage, earlier indication of an intrusion, quicker assessment of the nature of the attack, and a more tailored and focused response. Electronic systems also provide the opportunity for fewer individuals to be assigned to traditional guard duty activities.

While utilizing security technology enhances the capability of the guard force, it places greater demands on the alertness, judgment and training of guard force personnel.

- o Personal equipment
- o Arms munitions
- o Vehicles
- o Communications
- o Electronic security technology
    - -intrusion detection systems
    - -automated entry and access control
    - -control/display and information processing monitor
    - -surveillance and assessment (CCTV)

**SYSTEM SECURITY ENGINEERING**

The six steps of system security engineering.

Security technology is most useful when it is integrated within an overall security program. Without the right interface with policies and procedures, facilities, equipment, and especially personnel, security technology will contribute very little toward preventing or reacting to security problems. Systems security engineering is a systems approach to providing that interface between the overall security program and electronic security technology.

1. Analysis & Planning

   Operational considerations

2. Design & Specification

   Environmentally determined systems performance specifications

3. Engineering

   Equipment selection

4. System Integration

   Putting it all together

5. Installation

   The art of proper installation

6. Support

   Maintenance and support

<u>Analysis & Planning</u>

Evaluating security needs of specific sites according to potential threats and operating vulnerability. Once the requirements have been determined, defining performance specifications. (How quickly should the system react? How many people will access the system?). These critical planning and evaluation steps will determine the kind of program best suited to the particular security problems and which systems may be candidates for the site.

<u>Design & Specification</u>

On-site inspection taking into consideration the total environment (power, terrain, and climatic conditions among many others). Included in this step are trade-off analyses, weighing advantages and disadvantages of critical components. This step culminates with system specifications and cost estimates.

Engineering

After defining how individual components will work together, the right hardware and software for the job is selected. The strengths and weaknesses of particular subsystems and software programs, currently available, illuminate the choices. Finally, specialty engineering takes into consideration reliability, maintainability, logistics requirements, etc.

System Integration

Evaluation of the performance of the system, integration of the hardware and software, and definition and implementation of the technical, logistical, and operational needs, including manuals, procedures, and policies.

Installation

Analysis and preparation of the site, assembly, installation, and thorough checkout of the system.

Support

Training of personnel, supplying the spare parts, and maintaining the system.

## THE BASICS OF THE PHYSICAL SECURITY PROGRAM

In applying system security engineering to the car bomb threat, it is necessary to first review the basics of how your security should work in general.

- Create enhanced security awareness
- Conscientiously apply existing rules & procedures
- Move mission critical activities to most protected area
- Restrict mission critical areas to essential personnel
- Check all personnel and vehicles entering restricted areas with equal thoroughness--no exceptions

**CAR BOMB ATTACK PREVENTION**

Under ideal circumstances, which by definition never exist, you would want to carry out the recommendations shown below:

- o Keep all vehicles beyond distance where a detonation could incapacitate the unit being protected.
- o Minimize possible vehicle approach speed.
  - Maintain low speed limits.
  - Employ active and passive barriers.
- o Vector all vehicles away from potential target on final approach-make vehicle miss target if it continues beyond final checkpoint.
  - Use hairpin curve road design.
  - Active and passive barriers.
- o Reduce the number of vehicles which must approach critical areas.
  - Relocate non-critical assets away from critical ones.
- o Check <u>all</u> vehicles approaching critical areas thoroughly.
  - Reduce potential for checking to become routine and superficial.
  - Reduce potential for deceptive entry.

**CONCLUSION**

We anticipate that the car bomb threat will intensify as it is used increasingly against mission critical units at your facilities. The threat needs to be countered in the context of your comprehensive security effort. In each case where capital or operating expenses are being made. We strongly recommend that you follow the system security engineering procedure. This will insure that the money is spent in the most appropriate manner.

## DO YOU NEED PENN CENTRAL TECHNICAL SECURITY COMPANY'S TOTAL SECURITY CAPABILITY?

Today there is a puzzling array of security products and services in the marketplace. You have seen it all...demonstrations, exhibits, specification sheets, colorful company brochures, and salespeople touting one product or another as the panacea for all your security problems.

Amid the hoopla, you still have serious underlying doubts concerning security systems.

- What type of security system is needed?
- Is it the right technology?
- Which products should be selected?
- Which manufacturer(s) should be chosen?
- Who is going to interpret the manufacturer's mumbo jumbo concerning capabilities, performance, and warranties?
- Will all of the components function together?
- Who will install the security system?
- What provisions are available for maintenance and repair service?
- Will the manufacturer, installer, maintenance, and repair people take a vested interest in your security system?
- What is the best price?

Total Security Capability is just a phone call away. Penn Central Technical Security Company can remove the mystery surrounding security systems and their components. We can work with you to define your security problem and its solution. The bottom line result is a comprehensive security program including a tangible security system that satisfies your needs today and tomorrow.

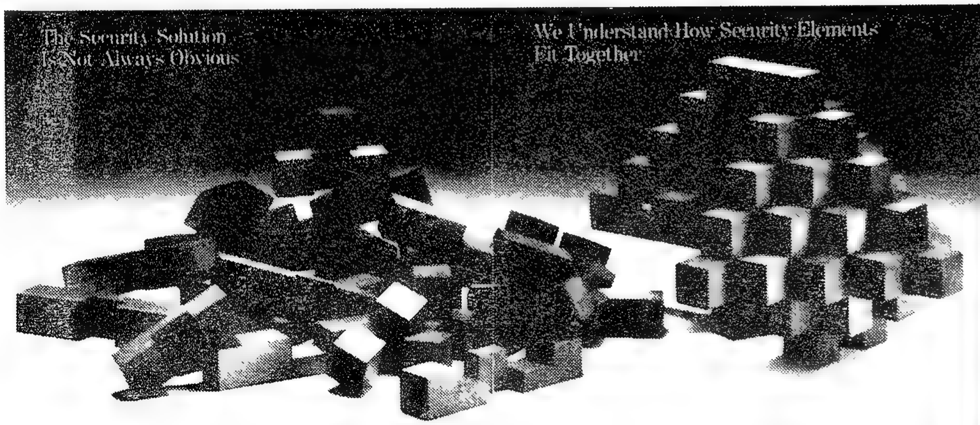
## WHAT IS THE PENN CENTRAL TECHNICAL SECURITY COMPANY?

Penn Central Technical Security Company is a subsidiary of the Penn Central Corporation, a Fortune 200 company with interests in electronics, telecommunications, defense, and energy.

We are a security services company engaged in the analysis, design, installation, and maintenance of sophisticated security systems and fully comprehensive programs.

Security is our only business. Our work is focused to meet the terrorist and criminal threat on a practical and effective basis.

We develop security programs and engineer and integrate security systems to help protect military installations, airports, power plants, commercial and industrial facilities housing sensitive information or high value equipment. We also develop programs and provide services related to the unique security needs of key personnel such as Ambassadors, Chief Executive Officers, and other VIP's.

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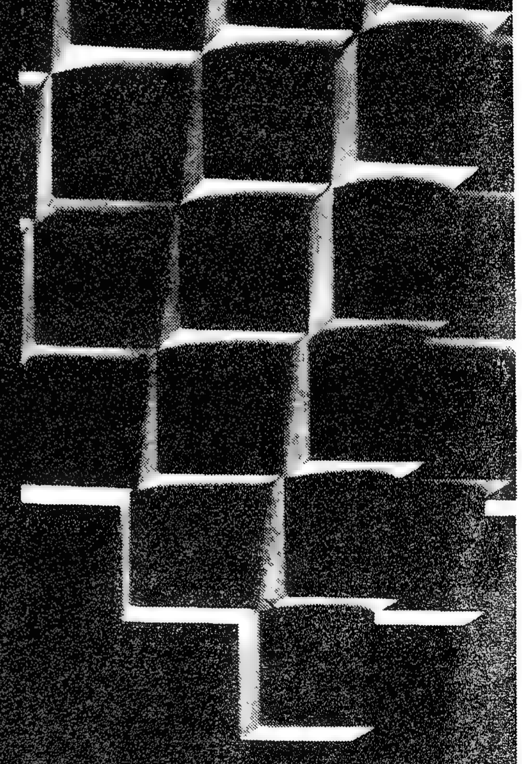
Suite 1800
Charleston, SC 29418

**PENN CENTRAL TECHNICAL SECURITY CO.**

Total Security Capability

**PENN CENTRAL TECHNICAL SECURITY CO.**



Total Security Capability

## PEOPLE AND EXPERIENCE MAKE THE DIFFERENCE.

Penn Central Technical Security Company represents over 20 years of experience in the security industry. We have designed and installed over 100 security systems throughout the world for the Government, including the Departments of Defense, State, and Energy, and a variety of commercial and industrial firms.

Our personnel are security systems and engineering professionals, with extensive experience in government security, including the military and the U.S. Secret Service. It is precisely this blend of operational experience and technical expertise that sets us apart in the security industry.

Another big difference between us and any other security company is the Penn Central Technical Security holistic approach to your security needs. We call it systems security engineering.

## WHAT IS SYSTEMS SECURITY ENGINEERING?

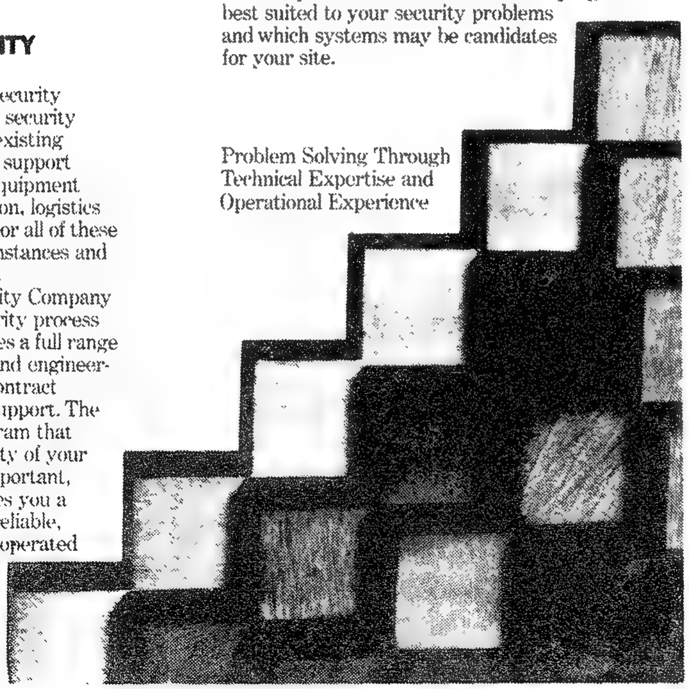
The Penn Central Technical Security Company designs and installs new security systems, maintains and upgrades existing systems, and provides operational support services such as security audits, equipment evaluations, training, documentation, logistics system design, etc. We custom tailor all of these activities to your particular circumstances and the nature of the threats you face.

Penn Central Technical Security Company leads you through the entire security process step by step. This approach includes a full range of services from analysis, design and engineering, to installation (including subcontract management), maintenance, and support. The result is a complete security program that enhances and extends the capability of your guard force personnel. Equally important, systems security engineering gives you a security system that is effective, reliable, maintainable, and one that can be operated without a degree in engineering.

## SIX STEPS TO TOTAL SECURITY.

Technology is useful to security only when it is a reliable integrated component of an overall security program. Without the right interface with procedures, facilities, equipment, and especially personnel, technology will contribute very little toward preventing or reacting to the threat in the first place. We know that systems security engineering can achieve that interface on a cost effective basis. The following steps in that process can be applied in total, or adapted as your needs dictate.

1. Analysis & Planning: We evaluate your security needs according to potential threats and operating vulnerability. Once the requirements have been determined, we define performance specifications. (How quickly should the system react? How many people will access the system?) These critical planning and evaluation steps will determine the kind of program best suited to your security problems and which systems may be candidates for your site.



Problem Solving Through Technical Expertise and Operational Experience

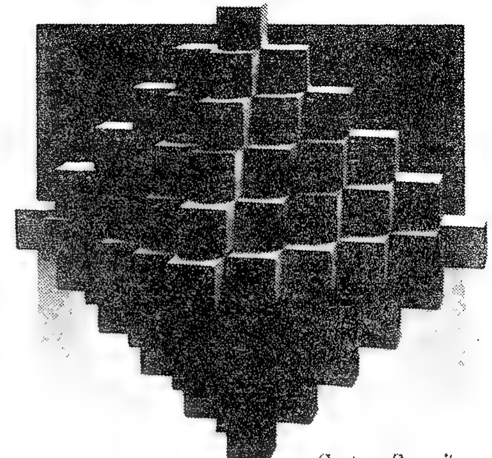
2. Design & Specification: An on-site inspection takes into consideration the total environment (power, terrain, and climatic conditions among many others). We include a trade-off analysis, weighing advantages and disadvantages of critical components. This step culminates with system specifications and cost estimates.

3. Engineering: After we define how individual components will work together, we select the right hardware and software for the job. We know the strengths and weaknesses of subsystems and software currently available, and we choose accordingly. We are not tied into one piece of hardware or software. Finally, specialty engineering takes into consideration the sensitivity, maintenance, and reliability of your security system.

4. System Integration: Here we evaluate the performance of the system, integrate the hardware and software, and define and implement the technical, logistical, and operational needs, including manuals, procedures, and policies.

5. Installation: This is one of the most vital parts of our service since an improperly installed system will not meet your needs. We analyze and prepare the site, and assemble, install, and thoroughly checkout the system before turnover.

6. Support: After your security system is in place, we are still on the job. We provide the support you really need. We train personnel; prepare plans, policies and procedures manuals; supply the spare parts and maintain the system.



System Security Engineering, the Total Solution

## PUT TOTAL SECURITY TO WORK FOR YOU.

We invite you to learn more about our capabilities. For information, call 609-983-0909 and ask for our Vice President, C. B. Kuhla.

The Penn Central Technical Security Company. From minor improvements to major upgrades, it is the total approach to your security needs.

R E F E R E N C E

# DEFINITIVE DESIGN ANALYSIS
# OF
# ACCESS POINTS
# TO
# U.S. ARMY INSTALLATIONS

Prepared for the
US ARMY ENGINEER DIVISION, HUNTSVILLE
HUNTSVILLE, ALABAMA

By
Black & Veatch
Engineers-Architects
Kansas City, Missouri

April 22, 1985
B&V Project No. 12021

TABLE OF CONTENTS

R E F E R E N C E

NUREG/CR-0484
MH-7814

# Vehicle Access and Control Planning Document

Prepared by J. E. Obermiller, H. J. Wait

Argonne National Laboratory
and
Mason & Hanger-Silas Mason Co., Inc.

Prepared for
U. S. Nuclear Regulatory
Commission

000663

Available from

GPO Sales Program
Division of Technical Information and Document Control
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

and

National Technical Information Service
Springfield, Virginia 22161

000664

REFERENCE

NUREG/CR-0485
MH-7814

# Vehicle Access and Search Training Manual

Prepared by J. E. Obermiller, H. J. Wait

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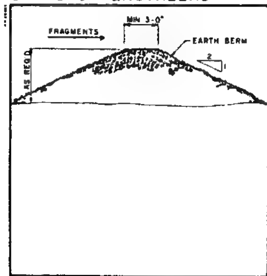
CORPS OF ENGINEERS U.S. ARMY

# ACCESS POINTS FOR U.S. ARMY INSTALLATIONS

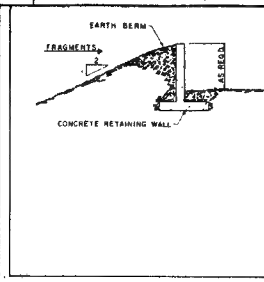
## DEFINITIVE DRAWINGS

US ARMY ENGINEER DIVISION, HUNTSVILLE
CORPS OF ENGINEERS
HUNTSVILLE, ALABAMA

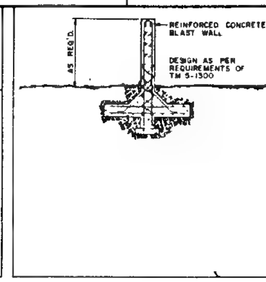
CORPS OF ENGINEERS | U. S. ARMY



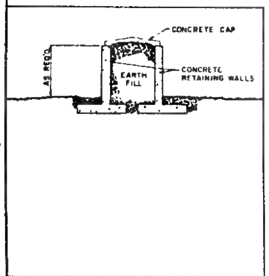

BB-1 EARTH BERM
SCALE NONE



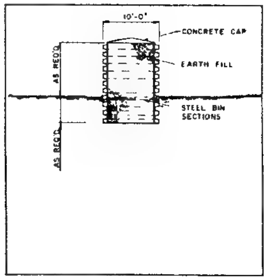

BB-2 RETAINING WALL
SCALE NONE



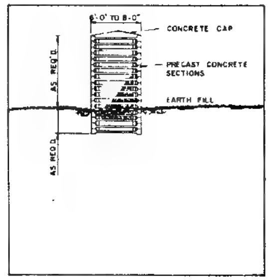

BB-3 CONCRETE WALL
SCALE NONE



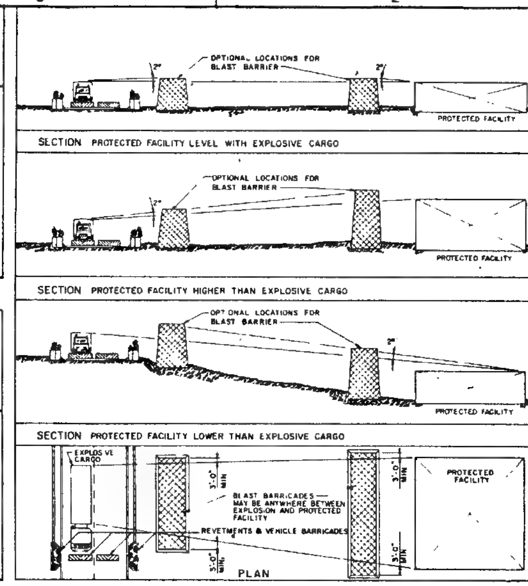

BB-4 EARTH FILLED WALL
SCALE NONE



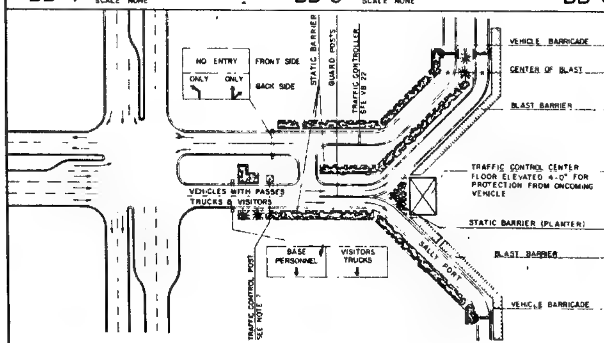

BB-5 STEEL BIN BERM
SCALE NONE




BB-6 CONCRETE CRIBBING
SCALE NONE




BB-7 GENERAL BLAST BARRIER
SCALE NONE




CONCEPT BF

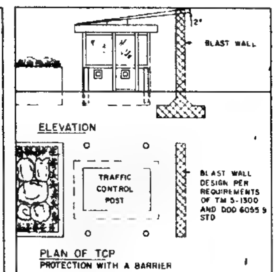
PREMISE: USE A PROTECTED TRAFFIC CONTROL CENTER WITHIN THE BLAST BARRIER

METHOD: USE SHARP TURNS TO CONTROL VEHICLE APPROACH SPEEDS. TRAFFIC CONTROL CENTER IS PART OF THE STATIC BARRIER AND BLAST BARRIER. VEHICLE BARRICADES ARE BEHIND A SECOND CURVE. TRAFFIC CONTROL CENTER IS NOT IN LINE OF SIGHT OF THE EXPLOSION BUT PARTIALLY PROTECTED BY THE BLAST BARRIER.

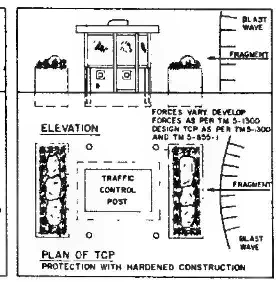
APPLICATION: USEFUL WHEN BOTH BLAST & SAFETY DISTANCES ARE LIMITED

LIMITATIONS: GUARD CANNOT SEE VEHICLE BARRICADE

B-6 CONCEPT BF
SCALE 1"=50'-0"




BB-8 PROTECTION OF TCP
SCALE 1/4"=1'-0"




BB-9 PROTECTION OF TCP
SCALE 1/4"=1'-0"

## BLAST & SAFETY ZONES (CONT)

### EXPECTED BLAST EFFECTS

THE FOLLOWING EXPECTED EFFECTS ARE FROM DOD 6055.9 STD

1. INHABITED BUILDING SAFETY DISTANCE - EXPOSURE TO 1.2 PSI

   UNSTRENGTHENED BUILDINGS MAY SUSTAIN DAMAGE UP TO 5% OF THE REPLACEMENT COST. OCCUPANTS OF BUILDINGS ARE PROVIDED A HIGH DEGREE OF PROTECTION FROM DEATH OR SERIOUS INJURY. MINOR INJURIES WOULD BE DUE TO FLYING GLASS AND BUILDING DEBRIS. PERSONNEL IN THE OPEN ARE NOT EXPECTED TO BE SERIOUSLY INJURED DIRECTLY BY BLAST. INJURIES DUE TO FRAGMENTS AND DEBRIS MAY BE EXPECTED.

2. PUBLIC ROADS SAFETY DISTANCE - EXPOSURE TO 2.3 PSI

   UNSTRENGTHENED BUILDINGS MAY SUSTAIN DAMAGE UP TO 20% OF THE REPLACEMENT COST. OCCUPANTS OF BUILDINGS MAY SUFFER TEMPORARY HEARING LOSS OR INJURY FROM SECONDARY BLAST EFFECTS SUCH AS BUILDING DEBRIS AND THE TERTIARY EFFECT OF DISPLACEMENT. PERSONNEL IN THE OPEN ARE NOT EXPECTED TO BE KILLED OR SERIOUSLY INJURED DIRECTLY BY BLAST. INJURIES DUE TO FRAGMENTS AND DEBRIS MAY BE EXPECTED. VEHICLES ON THE ROAD SHOULD SUFFER LITTLE DAMAGE UNLESS HIT BY A FRAGMENT OR UNLESS THE BLAST HAVE CAUSED MOMENTARY LOSS OF CONTROL.

3. UNBARRICADED BLAST DISTANCE - EXPOSURE TO 3.5 PSI

   DAMAGE TO UNSTRENGTHENED BUILDINGS WILL BE OF A SERIOUS NATURE AT 50% OR MORE OF THE TOTAL REPLACEMENT COST. THERE IS A 10 PERCENT CHANCE OF EARDRUM DAMAGE TO PERSONNEL. PERSONNEL INJURIES OF A SERIOUS NATURE OR POSSIBLE DEATH ARE LIKELY DUE TO FRAGMENTS, DEBRIS, FIREBRANDS OR OTHER OBJECTS. VEHICLES WILL INCUR EXTENSIVE, BUT NOT SEVERE, BODY AND GLASS DAMAGE CONSISTING MAINLY OF DISHING OF BODY PANELS AND CRACKS IN SHATTER-RESISTANT WINDOW GLASS.

4. BARRICADED BLAST DISTANCES - EXPOSURE TO 11 PSI

   UNSTRENGTHENED BUILDINGS WILL SUFFER SEVERE STRUCTURAL DAMAGE APPROACHING TOTAL DESTRUCTION. SEVERE INJURIES OR DEATH ARE TO BE EXPECTED FROM DIRECT BLAST, BUILDING COLLAPSE, OR TRANSLATION. VEHICLES WILL BE HEAVILY DAMAGED, PROBABLY TO THE EXTENT OF TOTAL LOSS. IMPROPERLY DESIGNED BARRICADES OR STRUCTURES MAY INCREASE THE HAZARD FROM FLYING DEBRIS, OR MAY COLLAPSE IN SUCH A MANNER AS TO INCREASE THE RISK TO PERSONNEL AND EQUIPMENT. BARRICADING IS REQUIRED. EXPOSED STRUCTURES WHEREIN PERSONNEL EXPOSURE IS SIGNIFICANT MAY REQUIRE HARDENING FOR NECESSARY PROTECTION.

### BLAST BARRIERS

BLAST BARRIERS SHALL BE DESIGNED AS PER DOD 6055.9 STD. PROPERLY CONSTRUCTED BARRICADES ARE EFFECTIVE AGAINST HIGH VELOCITY, LOW ANGLE FRAGMENTS ALTHOUGH THE BARRIERS MAY BE DESTROYED IN THE PROCESS. BARRIERS ALSO PROVIDE LIMITED PROTECTION AGAINST BLAST IN THE IMMEDIATE VICINITY. THEY DO NOT PROVIDE ANY PROTECTION AGAINST HIGH ANGLE FRAGMENTS AND ARE INEFFECTIVE IN REDUCING THE BLAST PRESSURES IN THE FAR FIELD. THUS, EVERY EFFORT SHOULD BE MADE TO MAINTAIN THE BLAST AND SAFETY DISTANCES IN TABLE 2.

FRAGMENTS MOVE ALONG BALLISTIC TRAJECTORIES RATHER THAN STRAIGHT LINES. THEREFORE REASONABLE MARGINS IN BARRIER HEIGHT AND LENGTH MUST BE PROVIDED BEYOND THE MINIMUM DIMENSIONS WHICH BLOCK LINE OF SIGHT. THE MINIMUM BARRIER LENGTH AND HEIGHT SHALL BE DETERMINED AS PER DOD 6055.9 STD. REFER TO BB-7. THE MAXIMUM SLOPE OF AN EARTHEN BERM SHALL BE 1 VERTICAL TO 2 HORIZONTAL. EARTH FOR BARRIERS SHALL BE REASONABLY COHESIVE, FREE OF DELETERIOUS ORGANIC MATTER, TRASH, DEBRIS AND STONES HEAVIER THAN 10 POUNDS OR LARGER THAN 6 INCHES IN DIAMETER. THE LARGER STONES SHALL BE LIMITED TO THE LOWER CENTER OF THE BARRIER. COMPACTION AND SURFACE PREPARATION SHALL BE PROVIDED AS NECESSARY TO MAINTAIN STRUCTURAL INTEGRITY AND AVOID EROSION.

### PROTECTIVE CONSTRUCTION

THE PRESENT "STATE OF THE ART" IN PROTECTIVE CONSTRUCTION IS ADEQUATE TO PROTECT PERSONNEL AND FACILITIES FROM THE EFFECTS OF AN EXPLOSION AT THE BARRICADE. STRENGTHENING THE TRAFFIC CONTROL POST AND VISITOR CONTROL CENTER TO WITHSTAND LEVEL IV SMALL ARMS FIRE WILL PROVIDE REASONABLE PROTECTION AGAINST FRAGMENTS AND BUILDING DEBRIS BUT NOT NECESSARILY AGAINST BLAST. AT HIGH LEVELS OF BLAST PRESSURE IT WILL NOT BE POSSIBLE TO PROVIDE WINDOWS IN THE FACILITIES AT THE ACCESS POINTS. WITHOUT WINDOWS THESE FACILITIES WILL NOT BE EFFECTIVE. PROTECTIVE CONSTRUCTION SHALL BE DESIGNED AS PER TM 5-1300 AND TM 5-855-1.

| Symbol | Description | Date | Approved |
|---|---|---|---|
| | Revisions | | |

BLACK & VEATCH ENGINEERS-ARCHITECTS

DEPARTMENT OF THE ARMY

ACCESS POINTS FOR U. S. ARMY INSTALLATIONS

**BLAST BARRIERS**

| | | | |
|---|---|---|---|
| Dsn by: CJR | Ckd by: WFW | | |
| Reviewed by: | Date: JUNE 7, 1986 | Sheet reference number: - | Design file no.: |
| Approved by: | Drawing code: DEF 872 50 01 | | Sheet 12 of 12 |

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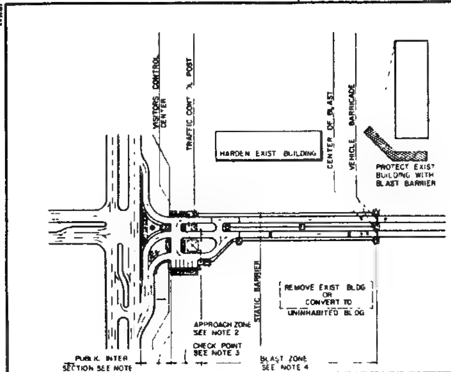
CORPS OF ENGINEERS | U. S. ARMY




**B-1 CONCEPT BA**
SCALE 1"=100'0"

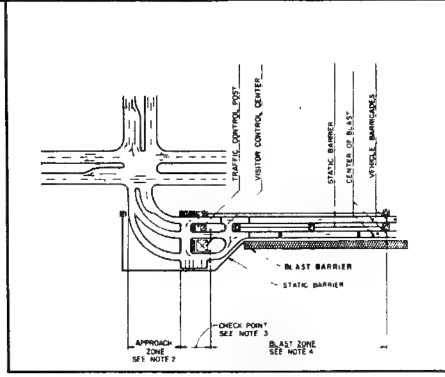
### CONCEPT BA

PREMISE: PROTECT INDIVIDUAL FACILITIES AGAINST THE EFFECTS OF A BLAST AT THE VEHICLE BARRICADE

METHOD: THE FOLLOWING METHODS MAY BE USED TO PROTECT BUILDINGS WITHIN THE SAFETY ZONE
1. REMOVE OR DEMOLISH THEM
2. CONVERT THEM TO UNINHABITED BUILDINGS
3. HARDEN THE BUILDING BY REMOVING THE WINDOWS AND STRENGTHENING THE STRUCTURE AND EXTERIOR WALLS
4. BUILD A BLAST BARRIER TO PROTECT THE BUILDING AGAINST FRAGMENTS FROM THE BLAST. THIS METHOD MAY NOT PROTECT THE BUILDING FROM OVERPRESSURE

APPLICATION: THIS CONCEPT WILL WORK IF THE BUILDINGS ARE SCATTERED, FEW IN NUMBER AND AT LONG DISTANCES FROM THE ACCESS POINTS

LIMITATIONS: THIS CONCEPT WILL NOT BE EFFECTIVE ON A DENSELY DEVELOPED INSTALLATION




**B-2 CONCEPT BB**
SCALE 1"=100'0"

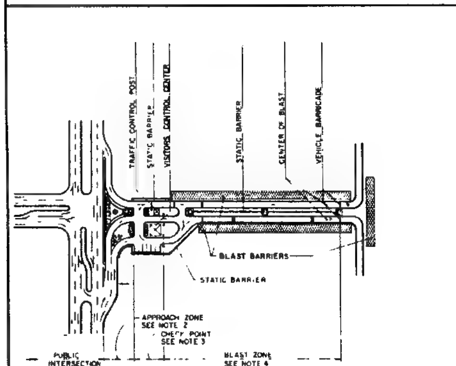
### CONCEPT BB

PREMISE: SEPARATE ACCESS POINT FROM THE INSTALLATION BY A SINGLE LONG BLAST WALL PARALLEL TO THE BASE PERIMETER

METHOD: PROVIDE THE ACCESS POINT ALONG THE PUBLIC ROAD AND PROVIDE A BLAST WALL BETWEEN THE ACCESS POINT AND THE MAIN BASE

APPLICATION: MAY BE USED WHEN THERE IS ADEQUATE OPEN SPACE ALONG THE PERIMETER OF A MILITARY INSTALLATION

LIMITATION: TALL BARRIERS WILL BE REQUIRED TO PROTECT MULTI-STORY BUILDINGS. THIS CONCEPT PROVIDES PROTECTION AGAINST FRAGMENTS BUT NOT NECESSARILY AGAINST THE OVERPRESSURE OF A BLAST




**B-3 CONCEPT BC**
SCALE 1"=100'0"

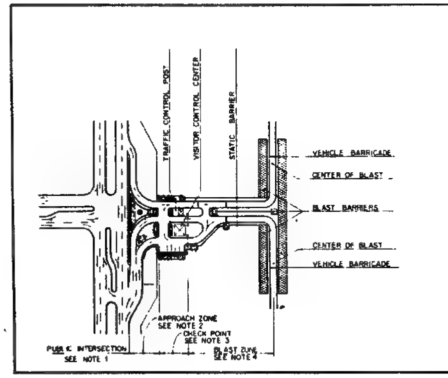
### CONCEPT BC

PREMISE: SURROUND THE ACCESS POINT WITH BLAST BARRIERS

METHOD: PROVIDE BLAST BARRIERS ALONGSIDE THE ROADS AT THE VEHICLE BARRICADES

APPLICATION: MAY BE USED WHEN THERE IS ADEQUATE OPEN SPACE WITHIN THE MAIN PART OF THE BASE TO INSERT THE ACCESS POINT AND BLAST BARRIERS

LIMITATION: TALL BARRIERS WILL BE REQUIRED TO PROTECT MULTI-STORY BUILDINGS. THIS CONCEPT PROVIDES PROTECTION AGAINST FRAGMENTS BUT NOT NECESSARILY AGAINST THE OVERPRESSURE OF A BLAST




**B-4 CONCEPT BD**
SCALE 1"=100'0"

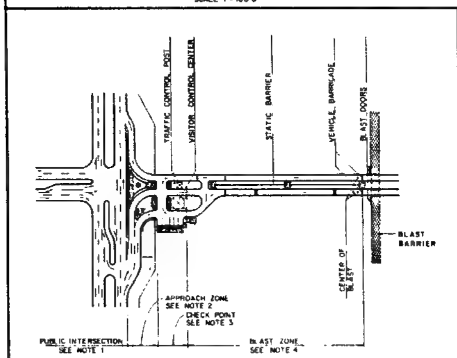
### CONCEPT BD

PREMISE: USE BLAST BARRICADES TO PROTECT BOTH THE CHECKPOINT AND THE MAIN PART OF THE BASE

METHOD: PROVIDE BLAST BARRIERS BETWEEN THE VEHICLE BARRICADES AND THE CHECKPOINT AS WELL AS BETWEEN THE BARRICADES AND THE MAIN PART OF THE BASE

APPLICATION: MAY BE USED WHEN THERE IS INADEQUATE SPACE FOR BOTH THE BLAST ZONE AND THE SAFETY ZONE

LIMITATIONS: GUARDS AT THE CHECKPOINT ARE NOT ABLE TO OBSERVE ACTIVITY AT THE BARRICADES. TALL BARRIERS WILL BE REQUIRED TO PROTECT MULTI-STORY BUILDINGS. THIS CONCEPT PROVIDES PROTECTION AGAINST FRAGMENTS BUT NOT NECESSARILY AGAINST THE OVERPRESSURE OF A BLAST




**B-5 CONCEPT BE**
SCALE 1"=100'0"

### CONCEPT BE

PREMISE: USE BLAST DOORS IN A BLAST WALL TO PROVIDE PROTECTION FOR THE INSTALLATION

METHOD: PLACE A BLAST WALL BETWEEN THE VEHICLE BARRICADES AND THE MAIN PART OF THE BASE. USE BLAST DOORS IN THAT WALL TO PROVIDE BASE ACCESS. BLAST DOORS WILL BE CLOSED NORMALLY

APPLICATION: THIS CONCEPT WILL WORK WELL IF THE VOLUME OF TRAFFIC THROUGH THE CHECKPOINT IS VERY LOW

LIMITATION: TALL BARRIERS WILL BE REQUIRED TO PROTECT MULTI-STORY BUILDINGS. THIS CONCEPT PROVIDES PROTECTION AGAINST FRAGMENTS BUT NOT NECESSARILY AGAINST THE OVERPRESSURE OF A BLAST

## BLAST & SAFETY ZONES

### REFERENCES

| | |
|---|---|
| DOD 6055.9 STD | DOD AMMUNITION AND EXPLOSIVE SAFETY STANDARDS |
| TM 5-855-1 | FUNDAMENTALS OF PROTECTIVE DESIGN FOR CONVENTIONAL WEAPONS |
| TM 5-1300 | STRUCTURES TO RESIST THE EFFECTS OF ACCIDENTAL EXPLOSIONS |

### SAFETY ZONE ($40W^{1/3}$ AND $24W^{1/3}$)

IF A TERRORIST VEHICLE STRIKES A VEHICLE BARRICADE, THE EXPLOSIVE CARGO OF THAT VEHICLE MAY EXPLODE. THEREFORE, PERSONNEL AND FACILITIES OF THE MILITARY INSTALLATION MUST BE PROTECTED FROM THE EFFECTS OF SUCH AN EXPLOSION. THE MOST EFFECTIVE PROTECTION MAY BE PROVIDED BY SEPARATING THE ACCESS POINTS FROM THE MAIN AREAS OF THE INSTALLATION. THIS SEPARATION IS CALLED THE SAFETY ZONE. THE SAFETY ZONE IS MEASURED FROM THE VEHICLE BARRICADE TO ANY INHABITED BUILDINGS (INHAB. BLDG.), PUBLIC ROADS (PUB. ROAD) AND RECREATION AREAS (PUB. ROAD). THE SAFETY ZONE SHALL EXTEND IN ALL DIRECTIONS FROM THE VEHICLE BARRICADE. THE DISTANCE IS DETERMINED BY THE WEIGHT OF THE EXPLOSIVE CHARGE AND THE FACILITY OR PERSONNEL TO BE PROTECTED. REFER TO TABLE 2 BELOW FOR THESE SAFETY DISTANCES. IF THE DISTANCES BELOW CANNOT BE ATTAINED, IT MAY BE NECESSARY TO PROTECT INHABITED FACILITIES AND PERSONNEL. BEFORE PROVIDING BLAST PROTECTION, CONDUCT AN ANALYSIS AS PER TM 5-1300. LIMITED BLAST PROTECTION MAY BE PROVIDED USING THE BLAST BARRIER CONCEPTS.

### BLAST ZONE ($18W^{1/3}$ AND $9W^{1/3}$)

SECURITY PERSONNEL AT THE ACCESS POINT SHALL ALSO BE PROVIDED BLAST PROTECTION IF AT ALL POSSIBLE. THIS PROTECTION MAY BE PROVIDED BY SEPARATING THE CHECKPOINT FROM VEHICLE BARRICADES BY A BLAST ZONE. THE BLAST ZONE IS MEASURED FROM THE BARRICADES TO THE NEAREST TRAFFIC CONTROL POST OR THE VISITOR CONTROL CENTER. REFER TO TABLE 2 BELOW, COLUMN (UNBAR.) FOR THE REQUIRED BLAST ZONE DISTANCES. IF THE REQUIRED DISTANCE CANNOT BE ATTAINED, THE NEXT COLUMN (BAR.) MAY BE USED IF A BLAST BARRICADE IS PLACED BETWEEN THE CHECKPOINT FACILITIES AND THE VEHICLE BARRICADES. REFER TO BLAST CONCEPT BD AND SHEET 12.

### FRAGMENTS

THE ABOVE ZONES ARE BASED UPON QUANTITY-DISTANCE TABLES RELATED TO BLAST OVERPRESSURES. THE DANGER DUE TO FRAGMENTS AND FLYING DEBRIS WILL EXTEND BEYOND THE DISTANCES IN TABLE 2. FOR QUANTITIES OF TNT OF 100 LBS OR LESS, THE FRAGMENT ZONE EXTENDS 670 FEET. FOR QUANTITIES OVER 100 LBS, THE FRAGMENT ZONE EXTENDS 1250 FT. LOW ANGLE HIGH VELOCITY FRAGMENTS MAY BE INTERCEPTED BY BLAST BARRIERS AS SHOWN ON SHEET 12.

### BLAST BARRIERS

PROPERLY CONSTRUCTED BLAST BARRIERS ARE EFFECTIVE AGAINST HIGH VELOCITY, LOW ANGLE FRAGMENTS. THEY ALSO PROVIDE LIMITED PROTECTION AGAINST BLAST OVERPRESSURES IN THEIR IMMEDIATE VICINITY. THEY DO NOT PROVIDE ANY PROTECTION AGAINST HIGH ANGLE FRAGMENTS AND ARE NOT EFFECTIVE IN REDUCING THE BLAST OVERPRESSURES IN THE FAR FIELD (DISTANCES GREATER THAN 6 TIMES THE HEIGHT OF BARRIER). FOR THIS REASON, EVEN WHEN BARRICADES ARE USED, AS IN SCHEMES BD THROUGH BF, INDIVIDUAL BUILDINGS MAY STILL REQUIRE PROTECTION TO PROTECT THEM AND THEIR OCCUPANTS FROM THE EFFECTS OF BLAST OVERPRESSURE.

WHEN BLAST BARRIERS ARE USED ALONGSIDE THE ACCESS POINTS, AS IN THE CONCEPTS SHOWN ON THIS DRAWING, THE OVERPRESSURES AT THE CHECKPOINTS MUST BE CHECKED AS PER TM 5-1300. DUE TO THE REFLECTED OVERPRESSURES SET UP BY THE BLAST BARRIERS, THE BLAST DISTANCES GIVEN IN THE TABLE BELOW MAY NOT APPLY.

### TABLE 2 BLAST & SAFETY DISTANCES

| AMOUNT OF MATERIAL IN POUNDS OF TNT | SAFETY DISTANCES | | BLAST DISTANCES | |
|---|---|---|---|---|
| | INHAB. BLDG. | PUB. ROADS | UNBAR. | BAR. |
| LESS THAN 50 LBS | 150 FT | 90 FT | 60 FT | 30 FT |
| 50-100 LBS | 190 | 115 | 80 | 40 |
| 100-300 | 275 | 160 | 120 | 60 |
| 300-1000 | 400 | 240 | 180 | 90 |
| 1000-2000 | 505 | 305 | 230 | 115 |
| 2000-4000 | 635 | 380 | 285 | 145 |
| 4000-7000 | 770 | 460 | 340 | 170 |
| 7000-10,000 | 865 | 520 | 390 | 195 |
| 10,000-15,000 | 980 | 585 | 450 | 225 |
| 15,000-20,000 LBS | 1090 FT | 655 FT | 490 FT | 245 FT |
| PEAK OVERPRESSURE | 1.2 PSI | 2.3 PSI | 3.5 PSI | 11 PSI |
| DISTANCE FACTOR | $40W^{1/3}$ | $24W^{1/3}$ | $18W^{1/3}$ | $9W^{1/3}$ |

ADAPTED FROM DOD 6055.9 STD. W = NET WEIGHT OF HIGH EXPLOSIVE MATERIAL

| Symbol | Description | Date | Approved |
|---|---|---|---|
| | | | |

Revisions

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ENGINEERS-ARCHITECTS
KANSAS CITY, MISSOURI

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
MILITARY CONSTRUCTION – ENGINEERING DIVISION
WASHINGTON, D.C.

Site adapt A/E:

U.S. Army Corps of Engineers

# ACCESS POINTS FOR U. S. ARMY INSTALLATIONS

# BLAST SAFETY CONCEPTS

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| Dwn by: KLL | Ckd by: WFM | | |
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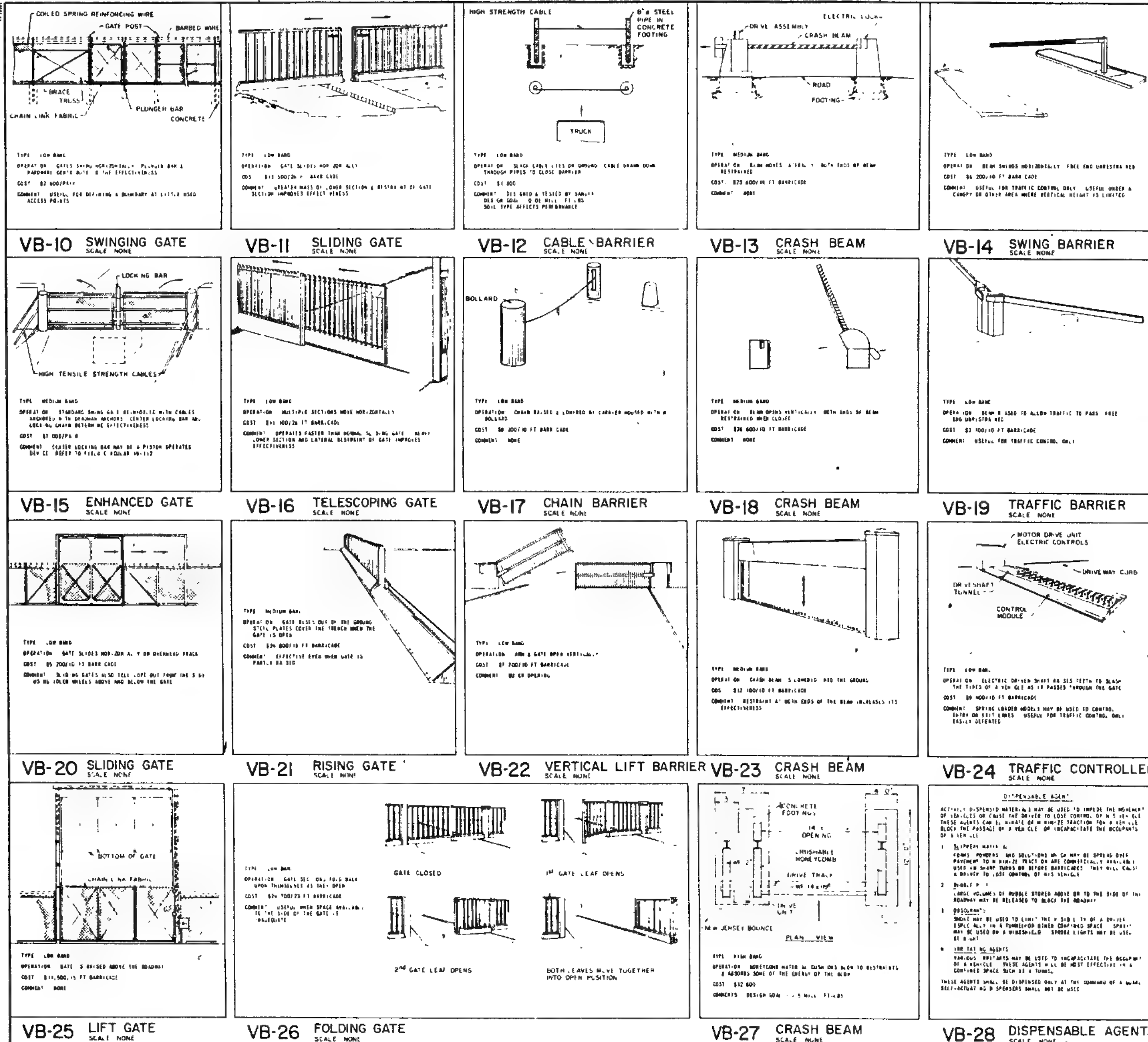
CORPS OF ENGINEERS | U. S. ARMY




## VEHICLE BARRICADES (CONT)

### MANUFACTURERS

THE BARRICADES SHOWN ON THESE DRAWINGS ARE COMMERCIALLY AVAILABLE. SOME HAVE BEEN TESTED AND TEST DATA IS AVAILABLE FROM THE MANUFACTURERS.

THE FOLLOWING MANUFACTURERS OF VEHICLE BARRICADES HAVE BEEN IDENTIFIED. UNDOUBTEDLY THERE ARE MANY OTHERS. THE FOLLOWING ARE NOT TO BE TAKEN AS APPROVED MANUFACTURERS BUT ARE LISTED ONLY TO PROVIDE POTENTIAL USERS WITH SOURCES OF INFORMATION.

| SYMBOL | MANUFACTURER | SYMBOL | MANUFACTURER |
|---|---|---|---|
| B | BALLISTIC SHELTERS CORP ALEXANDRIA VA (703) 548-8123 | FD | FOLGER ADAMS CO ELMONT IL (312) 738-3900 |
| B&W | BABCOCK & WILCOX LYNCHBURG VA (804) 385-2100 | FR | FRONTIER MACHINERY CO INC CHEEKTOWAGA NY (716) 885-1010 |
| B&B | B&B ELECTROMATIC CORP NORWOOD LA (504) 629-5234 | G | GHE LTD BRISTOL ENGLAND TELEX 449375 REPRESENTED IN US BY INTERFACE INC ARLINGTON VA (703) 525-1982 |
| D | DELTA SCIENTIFIC CORP BURBANK CA (818) 841-2787 | H | HORSNELLS CO MONTGOMERY AL (205) 284-2673 |
| EL | ELKASTA SALZGITTER W GERMANY TELEX 0 54 473 ELKO D | R | ROBOT INDUSTRIES INC DEARBORN MI (313) 846-2623 |
| EN | ENTWISTLE CO HUDSON MA (617) 481-4000 | T | TIRETRAP WASHINGTON NJ (201) 689-5380 |

### DESIGN PARAMETERS

A VEHICLE MOVING TOWARD A BARRICADE HAS KINETIC ENERGY DETERMINED BY THE VEHICLE'S WEIGHT AND SPEED. ON IMPACT WITH THE BARRICADE, SOME OF THIS ENERGY IS CONVERTED TO HEAT, SOUND AND PERMANENT DEFORMATION OF THE VEHICLE. THE REMAINDER OF THE KINETIC ENERGY MUST BE ABSORBED BY THE BARRICADE IF THE VEHICLE IS TO BE STOPPED. THE KINETIC ENERGY OF A VEHICLE VARIES LINEARLY WITH THE VEHICLE'S WEIGHT AND BY THE SQUARE OF ITS SPEED. THUS, SPEED IS MORE OF A DETERMINATE OF THE KINETIC ENERGY OF A VEHICLE THAN ITS WEIGHT. THE STANDARD ILLUSTRATION IS THE VW TRAVELING AT 60 MPH HAVING MORE HITTING POWER THAN AN ARMORED CAR WEIGHING 10 TIMES THE VW BUT ONLY TRAVELING AT 10 MPH.

IF THE VEHICLE'S WEIGHT AND SPEED EXCEED THE DESIGN PARAMETERS OF A BARRICADE, ONE OF TWO EVENTS WILL OCCUR. THE BARRICADE MAY BREAK LOOSE FROM ITS RESTRAINTS ALLOWING THE VEHICLE TO CONTINUE WITH MINIMAL DAMAGE. HOWEVER, IF THE BARRICADE CAUSES SUFFICIENT DAMAGE TO THE VEHICLE OR THE OCCUPANTS BEFORE IT FAILS, THE VEHICLE WILL BE UNABLE TO CONTINUE. THE LOW BAND BARRICADES LIKE CHAIN LINK GATES WILL FAIL IN THE FORMER MANNER. HOWEVER, THE HIGH BAND BARRICADES WILL FAIL IN THE SECOND MANNER. IF A BARRICADE IS DAMAGED TO THE POINT WHERE IT MUST BE REPLACED OR ITS CONCRETE HOUSING REPAIRED, THE LOSS WILL BE SLIGHT IF IT SUCCEEDS IN STOPPING THE THREAT.

### BARRICADE SELECTION

THE CONCEPTS SHOWN ENVISION ACTIVE BARRIERS OR BARRICADES. HOWEVER, THE SELECTION OF THE BARRICADE IS LEFT TO THE LOCAL SECURITY PLANNERS. SELECTION SHOULD BE MADE ON THE BASIS OF THE THREAT DEFINED, THE TERRAIN ENCOUNTERED, THE SPEED OF DEPLOYMENT AND THE COST OF THE BARRICADES. OTHER FACTORS TO CONSIDER ARE THE MAINTENANCE COSTS, THE REPLACEMENT OR REPAIR COSTS SHOULD THE BARRICADE EVER BE USED, AND THE SAFETY OF INNOCENT PERSONS CAUGHT BY THE BARRICADE WHEN IT IS DEPLOYED. IT SHOULD BE NOTED THAT ALL OF THESE BARRICADES, WITH THE POSSIBLE EXCEPTION OF THE ARRESTING NET, REPRESENT A LETHAL FORCE TO ANY ONCOMING VEHICLE. IF ONE OF THESE BARRICADES IS DEPLOYED TO HALT THE THREAT, ANY OTHER TRAFFIC WILL ENCOUNTER THE SAME LETHAL BARRIER QUITE UNEXPECTEDLY. THE WIDTHS OF SOME BARRICADES MAY BE VARIED; OTHERS MAY BE PROVIDED IN GREATER OR LESSER MULTIPLES. THESE CHANGES WILL VARY THE COSTS OF THE BARRICADES AND THEIR EFFECTIVENESS AGAINST SOME THREATS.

### IMPACT ENERGY

IMPACT ENERGY IN FT-LBS $= \dfrac{W \times V^2}{2 \times 32.2}$

W = VEHICLE WEIGHT IN POUNDS

V = VEHICLE SPEED IN FT PER SEC

$V = \dfrac{MPH \times 5280\ FT/MI}{3600\ SEC/HR}$

### NOTE

THE DESIGN CAPACITY OF EACH BARRICADE WAS CURRENT WITH THE PREPARATION OF THESE DRAWINGS. VARIOUS GOVERNMENT AGENCIES ARE DEVELOPING DESIGN STANDARDS TO APPLY TO THESE BARRICADES. THE MANUFACTURERS MAY MODIFY THEIR BARRICADES TO COMPLY WITH THESE STANDARDS AND IN DOING SO INCREASE THE DESIGN CAPACITY OF THEIR BARRICADES.

| Symbol | Description | Date | Approved |
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BLACK & VEATCH ENGINEERS-ARCHITECTS KANSAS CITY, MISSOURI

DEPARTMENT OF THE ARMY OFFICE OF THE CHIEF OF ENGINEERS

Site adapt A/E

ACCESS POINTS FOR U. S. ARMY INSTALLATIONS

VEHICLE BARRICADES II

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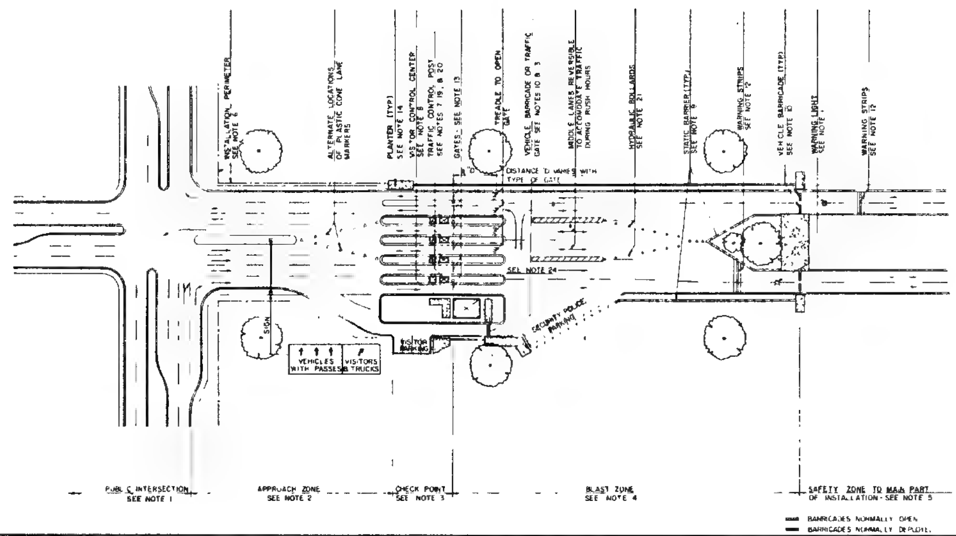
CORPS OF ENGINEERS | U. S. ARMY

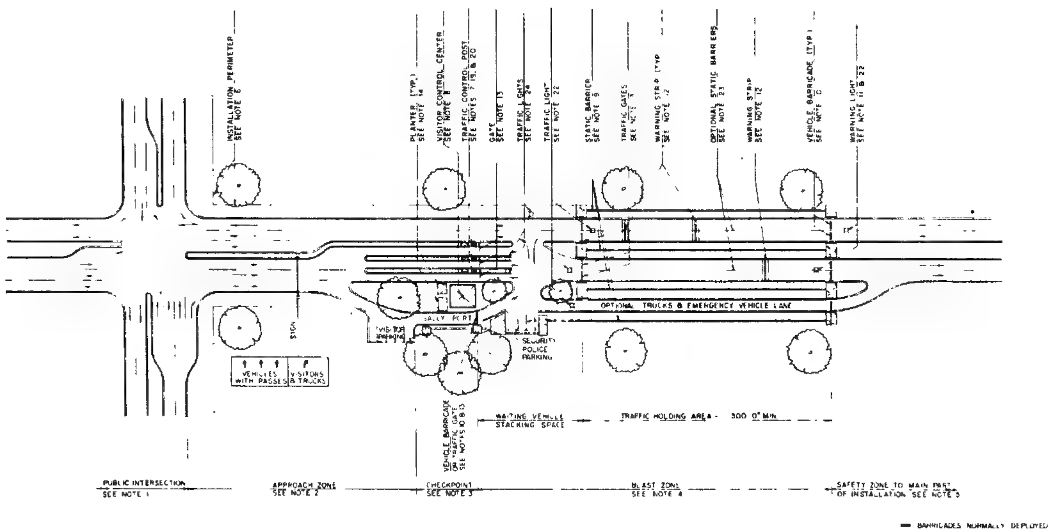



## CONCEPT C

- **PREMISE** INCREASE FLOW OF TRAFFIC WITH MULTIPLE "TOLL BOOTH" TYPE CHECKPOINTS AND SOME LANES REVERSIBLE TO ACCOMMODATE RUSH HOUR TRAFFIC IN BOTH DIRECTIONS. VEHICLE BARRICADES ARE ACTIVATED WHEN A "TOLL BOOTH" GATE IS VIOLATED.
- **OPERATION** INCOMING TRAFFIC IS SEPARATED BY THOSE VEHICLES WITH OR WITHOUT PASSES. THOSE WITHOUT PASSES ARE CLEARED THROUGH A SALLY PORT FORMED BY A SINGLE VEHICLE BARRICADE. THOSE VEHICLES WITH PASSES USE MULTIPLE LANES WHICH EACH HAVE A TOLL GATE ACTIVATED BY THE GUARD IN THE TRAFFIC CONTROL POST. THE TRAFFIC CONTROL POSTS COULD BE REPLACED BY CARD READERS, CLOSED CIRCUIT TELEVISION, OR SOME OTHER DEVICE MONITORED FROM THE VISITOR CONTROL CENTER. THE VEHICLE BARRICADES ARE DEPLOYED BY GUARDS WHEN A TOLL BOOTH GATE ARM IS VIOLATED. TOLL BOOTH GATES ARE PROVIDED IN THE EXIT LANES TO ACTIVATE THE VEHICLE BARRICADES WHEN A FORCED ENTRY OCCURS VIA THE EXIT LANES. THE EXIT LANE TOLL GATES ARE AUTOMATICALLY RAISED ON DEMAND FOR EXITING VEHICLES. TO MAKE THE CENTER LANES REVERSIBLE, THE LANE MARKINGS MUST BE FLEXIBLE. ON THE PUBLIC SIDE OF THE CHECKPOINT, PLASTIC CONES OR SOME OTHER LOW COST METHOD MAY BE USED TO PROPERLY CHANNEL TRAFFIC. ON THE INSTALLATION SIDE OF THE CHECKPOINT, THE INCOMING AND EXITING LANES MUST BE SEPARATED BY A VEHICLE BARRIER, SUCH AS A ROW OF OPERABLE BOLLARDS. OTHERWISE ALL VEHICLE BARRICADES MUST BE DEPLOYED WHEN A FORCED ENTRY OCCURS.
- **APPLICATION** THE CONCEPT IS APPLICABLE TO MANY DIFFERENT SITUATIONS BECAUSE OF ITS FLEXIBILITY IN MODIFYING THE NUMBER OF LANES.
- **LIMITATIONS** THE MULTIPLE LANES REQUIRE A LARGE NUMBER OF SECURITY PERSONNEL OR THE TECHNOLOGY TO REPLACE THEM.

SEE SHEETS 1-6 FOR ADDITIONAL NOTES

4 CONCEPT C
SCALE 1"=50'-0"




## CONCEPT D

- **PREMISE** ELIMINATE THE WINDOW OF VULNERABILITY OCCURRING WHEN THE VEHICLE BARRICADES ARE OPEN BY USING A TRAFFIC HOLDING AREA. THE TRAFFIC HOLDING AREA IS USED TO HOLD ENOUGH CARS TO BLOCK PASSAGE ALONG THE ROADWAY. THE TRAFFIC HOLDING AREA SHALL HOLD A LARGE NUMBER OF CARS TO MINIMIZE THE RESTRICTION TO FLOW DURING RUSH HOURS.
- **OPERATION** INCOMING VEHICLES FIRST CLEAR THE CHECKPOINT AREA AND THEN ENTER THE TRAFFIC HOLDING AREA. THE VEHICLE BARRICADES AT THE END OF THE TRAFFIC HOLDING AREA ARE DEPLOYED, BLOCKING PASSAGE TO ALL INCOMING TRAFFIC. WHEN ENOUGH CARS ARE IN THE TRAFFIC HOLDING AREA TO PREVENT A TERRORIST FROM FORCING HIS WAY DOWN THE ROAD, THE TRAFFIC GATES AT THE BEGINNING OF THE TRAFFIC HOLDING AREA ARE CLOSED AND THE VEHICLE BARRICADES ARE OPENED WHILE THE TRAFFIC HOLDING AREA EMPTIES. TRAFFIC WILL BACK UP BEHIND THE TRAFFIC GATES FORMING A NEW BARRIER AGAINST THE TERRORISTS. WHEN THE TRAFFIC HOLDING AREA IS EMPTY OF VEHICLES, THE BARRICADES ARE CLOSED, THE TRAFFIC GATES ARE OPENED, AND THE TRAFFIC ADVANCES TO THE VEHICLE BARRICADES TO REPEAT THE PROCESS. OUTGOING TRAFFIC GOES THROUGH A SIMILAR PROCESS WHEN LEAVING THE BASE. IF A TERRORIST FORCES HIS WAY PAST THE TRAFFIC GATES, THE VEHICLE BARRICADES WOULD BE IMMEDIATELY CLOSED TO LIMIT THE ADVANCE OF THE TERRORIST. DURING PERIODS OF HEAVY TRAFFIC, THE SAME EFFECT MAY BE ACHIEVED BY USING ONLY THE TRAFFIC LIGHTS TO LIMIT TRAFFIC MOVEMENT. INCOMING TRUCKS AND VISITORS USE A SEPARATE LANE AT THE CHECKPOINT TO AVOID TYING UP A NORMAL LANE OF TRAFFIC. VISITORS AND TRUCKS MAY REJOIN THE NORMAL FLOW OF TRAFFIC IN THE TRAFFIC HOLDING AREA OR USE AN OPTIONAL LANE BYPASSING THE TRAFFIC HOLDING AREA. THIS SEPARATE LANE MAY ALSO BE USED BY EMERGENCY VEHICLES. IF ADDITIONAL STATIC BARRIERS ARE USED TO SEPARATE ALL LANES OF TRAFFIC, THE TRAFFIC GATE AND VEHICLE BARRICADE IN EACH LANE MAY BE OPERATED INDEPENDENTLY OF THE GATES AND BARRICADES IN THE OTHER LANES. THIS METHOD WILL PROVIDE GREATER FLEXIBILITY DURING VARIOUS LEVELS OF TRAFFIC.
- **APPLICATION** THIS CONCEPT REQUIRES A LONG DISTANCE BETWEEN THE CHECKPOINT AND THE MAIN PART OF THE INSTALLATION.
- **LIMITATIONS** THE MULTIPLE LANES REQUIRE A LARGE NUMBER OF SECURITY PERSONNEL OR THE TECHNOLOGY TO REPLACE THEM.

SEE SHEETS 1-6 FOR ADDITIONAL NOTES

5 CONCEPT D
SCALE 1"=50'-0"

## GENERAL NOTES

1. PUBLIC INTERSECTION - THE PUBLIC INTERSECTION OCCURS AT THE PROPERTY LINE OF THE BASE. THE INTERSECTION MAY OCCUR AS A 4-WAY INTERSECTION BETWEEN TWO MAJOR ROADS, A 3-WAY INTERSECTION BETWEEN THE BASE ROAD AND A THROUGH ROAD, OR AN EXTENSION OF A SIDE ROAD.
2. APPROACH ZONE - THE LENGTH OF THE APPROACH ZONE WILL VARY DUE TO THE LAND AVAILABLE, THE SPEED OF ONCOMING VEHICLES, THE AMOUNT OF WEAVING REQUIRED TO SORT OUT INCOMING TRAFFIC, AND THE MEANS USED TO CONTROL THE SPEED OF INCOMING TRAFFIC. THE LENGTH OF THIS ZONE AND THE VOLUME OF TRAFFIC WILL DETERMINE THE NUMBER OF LANES REQUIRED TO PROVIDE ADEQUATE STACKING ROOM TO MINIMIZE CONGESTION IN THE PUBLIC INTERSECTION.
3. CHECKPOINT - THIS AREA INCLUDES THE TRAFFIC CONTROL POST (TCP), THE VISITOR CONTROL CENTER, AND THE SECTIONS OF ROAD USED TO CHECK ENTRY PASSES AND INSPECT VEHICLES.
4. BLAST ZONE - THE BLAST ZONE IS THE DISTANCE BETWEEN THE CHECKPOINT AND THE VEHICLE BARRICADE. THIS DISTANCE IS NECESSARY TO PROTECT THE GUARDS AT THE CHECKPOINT FROM AN EXPLOSION AT THE VEHICLE BARRICADE. THE DISTANCE IS DETERMINED BY THE WEIGHT OF THE EXPLOSIVE CHARGE (REFER TO TABLE 2 ON SHEET 11). SPECIAL PROTECTION FOR THE GUARDS MAY BE NECESSARY IF THESE DISTANCES CANNOT BE OBTAINED (REFER TO SHEET 12). THIS DISTANCE MUST ALSO BE GREAT ENOUGH TO PROVIDE ADEQUATE REACTION TIME FOR THE GUARDS AND BARRICADES TO RESPOND TO A FORCED ENTRY. IF THIS DISTANCE IS NOT GREAT ENOUGH, THEN THE VEHICLE BARRICADES SHOULD BE DEPLOYED EXCEPT WHEN AUTHORIZED VEHICLES ARE ALLOWED TO PASS. IF THIS DISTANCE BECOMES TOO GREAT, THE GUARDS AT THE CHECKPOINT MAY NOT BE ABLE TO CONTROL THE ACTIVITIES OF PERSONS STOPPED AT THE VEHICLE BARRICADE.
5. SAFETY ZONE - THE SAFETY ZONE IS THE DISTANCE FROM THE VEHICLE BARRICADE AND ANY INHABITED BUILDING, PUBLIC ROAD, OR OUTDOOR RECREATION AREA. THIS DISTANCE EXTENDS IN ALL DIRECTIONS AROUND THE VEHICLE BARRICADES AND IS NECESSARY TO PROTECT BASE PERSONNEL FROM AN EXPLOSION AT THE VEHICLE BARRICADE. THE DISTANCE IS DETERMINED BY WEIGHT OF THE EXPLOSIVE CHARGE AND THE FACILITY OR PERSONNEL TO BE PROTECTED. REFER TO TABLE 2 ON SHEET 11 FOR ADDITIONAL INFORMATION ON THIS DISTANCE. IF ADEQUATE DISTANCE IS NOT AVAILABLE, IT MAY BE NECESSARY TO PROTECT FACILITIES AGAINST THE EFFECTS OF A BLAST (SEE SHEET ).
6. BASE PERIMETER - THE BASE PERIMETER SHOWN ON THESE DRAWINGS IS THE OUTER MOST SECURED PERIMETER OF THE BASE. THIS PERIMETER MUST BE SECURED AGAINST THE IDENTIFIED THREAT. IF THE BASE PERIMETER AT THESE ACCESS POINTS IS NOT CAPABLE OF EXCLUDING THE SAME THREAT AS THE ACCESS POINTS, ADDITIONAL STATIC BARRIERS MAY BE REQUIRED TO KEEP THE THREAT ON THE ROADWAY.
7. TRAFFIC CONTROL POST (TCP) - DRAWINGS OF A TCP MAY BE FOUND ON SHEET 6. THE GUARD(S) IN A TCP ARE ONLY ABLE TO OBSERVE 2 TO 4 LANES OF TRAFFIC. ADDITIONAL TCPs WILL BE REQUIRED IF THERE ARE ADDITIONAL LANES OF TRAFFIC, IF THE VOLUME OF TRAFFIC IS HEAVY DURING PERIODS OF THE DAY, OR IF THE LEVEL OF SECURITY REQUIRES CLOSE CHECKING OF INCOMING TRAFFIC. THE TCP PROVIDES THE GUARDS A POSITION SECURE AGAINST THE HAZARDS OF TRAFFIC AND SMALL ARMS FIRE. ONE TCP SHOULD BE PROVIDED TO THE LEFT OF EACH INCOMING LANE OF TRAFFIC FOR THE BEST PROTECTION.
8. VISITOR CONTROL CENTER (VCC) - THE VISITOR CONTROL CENTER IS THE CONTROL CENTER FOR THE ACCESS POINT. THE CONTROLS FOR THE INTRUSION DETECTION EQUIPMENT, SURVEILLANCE MONITORS, VEHICLE BARRICADES, SECURITY LIGHTING, AND THE COMMUNICATION EQUIPMENT FOR THE ACCESS POINT ARE LOCATED IN THIS FACILITY. PERSONNEL IN THE VISITOR CONTROL CENTER ALSO HANDLE THE SPECIAL CASES OF VISITORS AND TRUCKS TRYING TO GAIN ENTRY TO THE INSTALLATION.
9. STATIC BARRIERS - STATIC BARRIERS MAY BE NATURAL FEATURES OF THE TERRAIN OR MANMADE DEVICES TO PROHIBIT THE PASSAGE OF A VEHICLE. IN THESE CONCEPTS, THESE BARRIERS ARE IDENTIFIED AS STATIC BARRIERS WITHOUT SPECIFYING ANY SPECIFIC DEVICE. VARIOUS STATIC BARRIERS ARE SHOWN ON SHEET 8. SPECIFIC DEVICES SHALL BE SELECTED AFTER CONSIDERING THE THREAT, THE LOCAL CONDITIONS, AND THEIR RELATIVE COSTS.
10. VEHICLE BARRICADES - VARIOUS VEHICLE BARRICADES ARE CURRENTLY BEING MANUFACTURED. SOME OF THESE BARRICADES ARE SHOWN ON SHEETS 9 & 10. SPECIFIC VEHICLE BARRICADES SHALL BE SELECTED AFTER CONSIDERING THE THREAT, THE LOCAL CONDITIONS, AND THEIR RELATIVE COSTS. THE FORCE OF ANY VEHICLE RAMMING MOST OF THESE DEVICES AT SPEEDS ABOVE 20 MPH MAY BE LETHAL TO THE OCCUPANTS OF THAT VEHICLE. THEREFORE, EXTREME CAUTION MUST BE EXERCISED TO ENSURE THAT THESE DEVICES ARE NOT ACTIVATED AT THE WRONG TIME.
11. WARNING LIGHTS - WARNING LIGHTS SHALL BE PLACED ABOVE ALL VEHICLE BARRICADES. WHEN THE BARRICADE OBSTRUCTS TRAFFIC, A RED STOP LIGHT SHALL BE DISPLAYED. AT OTHER TIMES A YELLOW FLASHING LIGHT SHALL BE USED.
12. WARNING STRIPS - A SERIES OF SMALL BUMPS IN THE ROAD SURFACE SHALL BE USED IN TWO OR MORE LOCATIONS PRECEDING THE VEHICLE BARRICADE TO SERVE AS A WARNING TO ALL DRIVERS.
13. GATE - A GATE, CRASH BEAM, OR VEHICLE CONTROL ARM MAY BE USED TO DEFINE THE STOPPING ZONE FOR VEHICLES GOING THROUGH THE CHECKPOINT. THE GATE IS NOT EXPECTED TO PREVENT PASSAGE OF A HIGH SPEED VEHICLE. HOWEVER, FORCING PASSAGE THROUGH THE GATE MAY BE USED TO ACTIVATE A VISUAL OR AUDIBLE ALARM OR EVEN THE VEHICLE BARRICADES.
14. PLANTERS - PLANTERS MAY BE USED AT THE TERMINATION POINT OF STATIC BARRIERS TO PROVIDE THEM WITH ADDITIONAL STRENGTH. PLANTERS THEMSELVES MAY BE USED AS STATIC BARRIERS AND TO PROTECT THE TCP AND VISITOR CONTROL CENTER AGAINST BEING RAMMED BY A VEHICLE. DETAILS OF PLANTERS ARE ON SHEET 8.
15. FRICTION DEVICES - CONTRARY TO GOOD HIGHWAY DESIGN, A SERIES OF DEVICES MAY BE USED TO IMPEDE THE FLOW OF VEHICLES MOVING ALONG A HIGHWAY. THESE FRICTION DEVICES INCLUDE:
    - NARROW TRAFFIC LANES
    - HIGH CURBS
    - SIDE OBSTRUCTIONS AT THE EDGE OF THE PAVEMENT
    - LOW OVERHEAD OBSTRUCTIONS
    - SPEED BUMPS, DIPS, WARNING STRIPS OR BREAKS IN THE PAVEMENT
16. SPEED/DIRECTION DETECTORS - SEVERAL ELECTRONIC DEVICES, INCLUDING RADAR, DETECTION LOOPS AND LIGHT BEAMS MAY BE USED TO DETECT VEHICLES TRAVELING AT EXCESSIVE SPEEDS OR VEHICLES TRAVELING IN THE WRONG DIRECTION. SEE SHEET 7.
17. RADAR DETECTION EQUIPMENT - RADAR ANTENNAS MAY BE MOUNTED ON A VERTICAL STANDARD, ON AN OVERHEAD STANDARD OR ABOVE THE TCP. THE RADAR DEVICE MUST BE CAREFULLY AIMED TO DETECT THE SPEED OR DIRECTION IN A SINGLE LANE. THE ANTENNA MAY NEED TO BE RECESSED IN A HOUSING TO REDUCE THE BEAM WIDTH.
18. TRAFFIC CONTROL GATES - THESE TOLL GATES ARE NORMALLY OPEN. WHEN THE SPEED/DIRECTION DETECTORS IDENTIFY AN IMPROPER APPROACH, THE GATES IN THOSE LANES WILL CLOSE. IF THE GATES ARE FORCED, THE ONCOMING VEHICLE WILL HAVE DECLARED THE INTENT TO FORCE AN ENTRY TO THE BASE.
19. ACCESS CONTROL - THE TRAFFIC CONTROL POST MAY BE SUPPLEMENTED WITH OR REPLACED BY A CARD READER SYSTEM OR TV CAMERA TO CONTROL ACCESS. A CARD READER SYSTEM WOULD BE CONTROLLED BY A SMALL COMPUTER AND COULD BE SET UP TO MONITOR AND CONTROL BASE ENTRY THROUGH THE USE OF ACCESS CARDS. THE TV CAMERA WOULD BE MONITORED BY PERSONNEL IN THE VISITOR CONTROL CENTER. SEE SHEET 7 FOR FURTHER INFORMATION.

| Symbol | Description | Date | Approval |
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Revisions

BLACK & VEATCH ENGINEERS-ARCHITECTS KANSAS CITY, MISSOURI

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C.

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| Site code: A.L. | ACCESS POINTS FOR U. S. ARMY INSTALLATIONS |
| Drawn by: K.L.L. / Checked by: W.F.W. | CONCEPTS C & D . |
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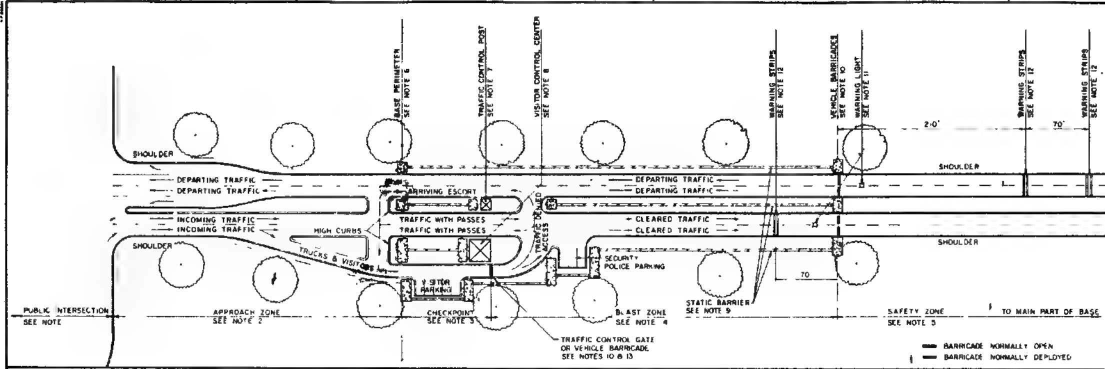
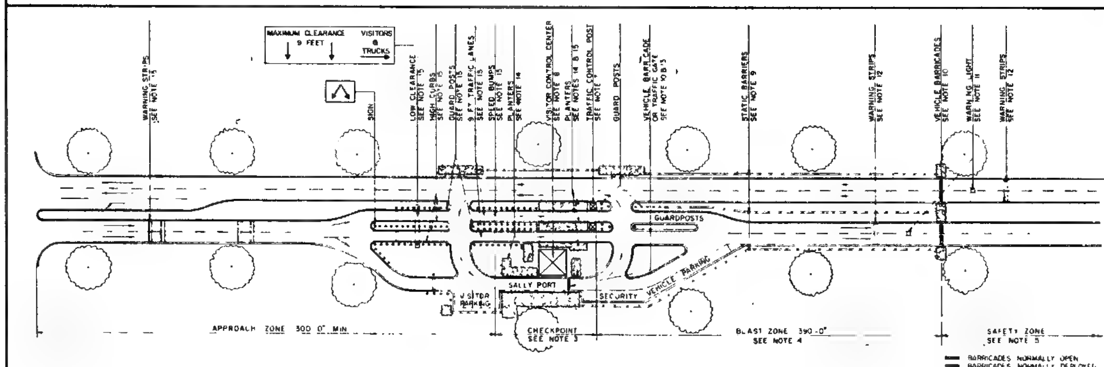
CORPS OF ENGINEERS | U. S. ARMY




1 GENERAL CONCEPT
SCALE 1"=50'-0"

## GENERAL CONCEPT

- EACH ACCESS POINT HAS 4 ZONES AS FOLLOWS
  - a. APPROACH ZONE: USED TO SORT OUT TRAFFIC, REDUCE THE SPEED OF TRAFFIC, PROVIDE STACKING SPACE FOR VEHICLES, AND IDENTIFY THREATENING VEHICLES
  - b. CHECKPOINT: USED TO CONDUCT ANY VEHICLE/PERSONNEL CHECKS
  - c. BLAST ZONE: USED TO PROTECT THE SECURITY FORCE AGAINST AN EXPLOSION AT THE VEHICLE BARRICADE
  - d. SAFETY ZONE: USED TO PROTECT PERSONNEL AND FACILITIES ON THE BASE AGAINST THE SAME EXPLOSION
- ALL CONCEPTS REQUIRE THE FOLLOWING ELEMENTS
  - a. STATIC BARRIERS TO LIMIT THE PATH OF VEHICLES
  - b. TRAFFIC CHECK POST (TCP) TO PROVIDE INDIVIDUAL GUARDS PROTECTION AGAINST TRAFFIC, WEATHER, AND ARMED INTRUDERS
  - c. VISITOR CONTROL CENTER (VCC) TO HOUSE GUARDS USED TO CHECK VISITORS AND TRUCKS AND TO OVERSEE CONDITIONS AT THE CHECKPOINT
  - d. VEHICLE BARRICADES TO PROVIDE A FINAL BARRIER AT THE ACCESS POINT AGAINST UNAUTHORIZED VEHICLES
- THE CHECKPOINT SHALL ACCOMMODATE THE FOLLOWING TRAFFIC AS SHOWN IN THE CONCEPTS
  - a. NORMAL INCOMING AND DEPARTING TRAFFIC
  - b. VISITORS
  - c. TRUCK TRAFFIC
  - d. VEHICLES DENIED ACCESS
  - e. VEHICLES WHICH REQUIRE A SEARCH
  - f. ARRIVING ESCORTS FOR VISITORS
- EACH ACCESS POINT SHALL HAVE 2 OR MORE FACILITIES FOR THE GUARD FORCE AT THE CHECKPOINT: 1 VCC AND 1 OR MORE TCP'S. MULTIPLE FACILITIES ARE NECESSARY FOR PROPER SURVEILLANCE OF THE ACCESS POINT AND FOR REDUNDANCY AGAINST TERRORISTS. AN ELEVATED CONTROL TOWER SHALL BE PROVIDED WHERE NECESSARY DUE TO THE TERRAIN OR THE REQUIRED LEVEL OF SECURITY
- VEHICLE BARRICADES ARE REQUIRED IN THE DEPARTING TRAFFIC LANES TO KEEP A TERRORIST FROM USING THESE LANES TO GAIN ENTRY TO THE BASE




2 CONCEPT A
SCALE 1"=50'-0"

## CONCEPT A

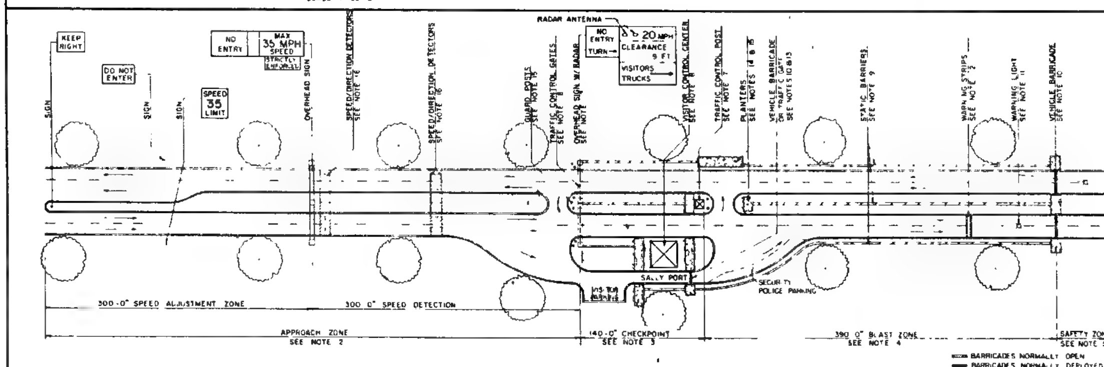
PREMISE: SLOW TRAFFIC BY USING TRAFFIC FRICTION DEVICES. THE NARROW TRAFFIC LANES WILL MAKE IT VERY DIFFICULT FOR A SPEEDING VEHICLE TO PASS WITHOUT COLLIDING WITH A FIXED OBJECT

OPERATION: A SERIES OF FRICTION DEVICES ARE USED TO SLOW TRAFFIC. THESE DEVICES INCLUDE WARNING AND SPEED BUMPS, REDUCTION IN THE NUMBER AND WIDTH OF LANES, HIGH CURBS, LATERAL OBSTRUCTIONS, AND OVERHEAD OBSTRUCTIONS. THESE DEVICES SLOW NORMAL TRAFFIC WHICH WILL ALSO OBSTRUCT A SPEEDING VEHICLE. TRAFFIC DETECTION DEVICES SUCH AS RADAR WILL IDENTIFY VEHICLES ENTERING THE EXIT LANES. A SEPARATE ENTRANCE LANE FOR VISITORS AND TRUCKS PASSES THROUGH A SALLY PORT FORMED BY A SINGLE VEHICLE BARRICADE. THIS BARRICADE WILL BE DEPLOYED NORMALLY. THE VEHICLE BARRICADES ON THE MAIN ROADS ARE NOT DEPLOYED NORMALLY. BOTH BARRICADES IN A SINGLE ROADWAY MUST BE DEPLOYED TO STOP A VEHICLE; HOWEVER, IT IS NOT NECESSARY TO DEPLOY ALL FOUR BARRICADES TO STOP A SINGLE ENTERING VEHICLE

APPLICATION: THE CONCEPT IS VERY FLEXIBLE IN APPLICATION AND DOES NOT DEPEND UPON HIGH TECHNOLOGY FOR ITS SUCCESS

LIMITATIONS: THE FRICTION DEVICES ARE POTENTIAL SAFETY HAZARDS TO NORMAL TRAFFIC. THIS CONCEPT REQUIRES AN APPROACH ZONE LONG ENOUGH TO ACCOMMODATE BACKED UP TRAFFIC

SEE SHEETS -4 FOR ADDITIONAL NOTES




3 CONCEPT B
SCALE 1"=50'-0"

## CONCEPT B

PREMISE: USE SPEED DETECTORS TO IDENTIFY THREATENING VEHICLES AND SOUND THE ALARM

OPERATION: DEVICES SUCH AS RADAR, DETECTOR LOOPS OR LIGHT BEAMS DETECT VEHICLES SPEEDING OR ENTERING THE EXIT LANES AND AUTOMATICALLY DEPLOY RELATIVELY LIGHTWEIGHT TRAFFIC CONTROL GATES. IF THE VEHICLE CRASHES THROUGH THE FIRST GATE, AN ALARM WILL SOUND. AT THE GUARD'S OPTION, THE VEHICLE BARRICADES FARTHER DOWN THE ROAD MAY ALSO BE DEPLOYED. THE PURPOSE OF THE TRAFFIC CONTROL GATES, WHICH ARE OPEN NORMALLY, IS TO PROVIDE A BARRIER WHOSE PENETRATION IDENTIFIES FORCEFUL ENTRY INTENT, BUT WHICH WILL NOT BE DEADLY TO DRIVERS, SUCH AS SPEEDERS OR MISCHIEVOUS TEENAGERS, WHO DO NOT INTEND FORCEFUL ENTRY. THE VEHICLE BARRICADES ARE DEPLOYED AS DESCRIBED FOR CONCEPT A

APPLICATION: A RELATIVELY LONG APPROACH ZONE WILL BE REQUIRED FOR VEHICLE SPEED ADJUSTMENT PRIOR TO SPEED MONITORING AND FOR SPEED MONITORING

LIMITATIONS: BECAUSE SIGNAGE IS NOT AS RELIABLE AS PHYSICAL FEATURES FOR SLOWING TRAFFIC, FALSE ALARMS ARE PROBABLE

SEE SHEETS 1-4 FOR ADDITIONAL NOTES

## REFERENCES

**DEPARTMENT OF THE ARMY**

| | |
|---|---|
| FM 19-30 | PHYSICAL SECURITY |
| TM-5-811-1 | ELECTRICAL POWER SUPPLY AND DISTRIBUTION |
| TM-5-853-1 | DESIGNING FOR SECURITY |
| TM-5-855-1 | FUNDAMENTALS OF PROTECTIVE DESIGN FOR CONVENTIONAL WEAPONS |
| TM-5-822-2 | GEN. PROVISION & GEOMETRIC DESIGN FOR ROADS, STREETS, WALKS AND OPEN STORAGE AREAS |
| TM-5-1300 | STRUCTURES TO RESIST THE EFFECTS OF ACCIDENTAL EXPLOSIONS |
| FIELD CIRCULAR 19-112 | USE OF BARRIERS IN COUNTERING TERRORISM SITUATIONS |

**DEPARTMENT OF THE NAVY**

| | |
|---|---|
| NAVFAC DM-5.12 | FENCING, GATES, AND GUARD TOWERS |
| NAVFAC DM-13.1 | PHYSICAL SECURITY |

**DEPARTMENT OF DEFENSE**

| | |
|---|---|
| DOD 6055.9 STD | DOD AMMUNITION AND EXPLOSIVE SAFETY STANDARDS |
| MIL-STD-398 | MILITARY STANDARD SHIELDS, OPERATIONAL FOR AMMUNITION OPERATIONS, CRITERIA FOR DESIGN OF AND TESTS FOR ACCEPTANCE |

**DEPARTMENT OF ENERGY**

| | |
|---|---|
| SAND 76-0554 | INTRUSION DETECTION SYSTEM HANDBOOK |
| SAND 77-0777 | BARRIER TECHNOLOGY HANDBOOK |

**NON GOVERNMENT PUBLICATIONS**

| | |
|---|---|
| UNDERWRITERS LABORATORIES UL 752 | STANDARD FOR SAFETY: BULLET-RESISTING EQUIPMENT |

**RELATED DRAWINGS**

| | |
|---|---|
| 40-16-08 | DRAWING: FENCES AND DETAILS |
| DEF 872-10-01 | DRAWING: WEAPONS STORAGE AREA, FENCE DETAIL AND CRASH BEAMS |
| DEF 812-30-01 | SECURITY LIGHTING SYSTEM |
| DEF 872-80-01 | PERIMETER WARNING SIGN |

## OVERALL OBJECTIVES

- ACCESS POINTS SHALL BE DESIGNED FOR THREE PURPOSES
  - a. THEY SHALL ASSIST THE SECURITY FORCE IN DETERRING, DENYING, OR AT THE LEAST DELAYING ENTRY TO A SINGLE TERRORIST OR A GROUP OF TERRORISTS INTENT ON GAINING ENTRY TO A MILITARY INSTALLATION BY MEANS OF FORCE
  - b. THEY SHALL PROTECT THE SECURITY FORCE AT THE CHECKPOINT AGAINST SMALL ARMS FIRE
  - c. THEY SHALL PROTECT THE PERSONNEL AND FACILITIES ON THE MAIN BASE AGAINST AN EXPLOSION AT THE VEHICLE BARRICADE
- ACCESS POINTS SHALL MINIMIZE THE FOLLOWING
  - a. UNDUE THREATS TO THE WELL BEING OF PERSONS HAVING LEGITIMATE REASONS FOR PASSING THROUGH THE ACCESS POINTS
  - b. UNDUE RESTRICTIONS TO THE FLOW OF TRAFFIC THROUGH THE ACCESS POINTS
- ACCESS POINTS SHALL PROVIDE THE FOLLOWING
  - a. OPERATIONAL FLEXIBILITY TO SUPPORT VARIOUS LEVELS OF SECURITY
  - b. FLEXIBILITY TO ACCOMMODATE A RANGE OF TRAFFIC CONDITIONS SUCH AS RUSH HOUR TRAFFIC AND VISITOR AND TRUCK TRAFFIC REQUIRING ADDITIONAL CHECKING
- IT IS DESIRABLE TO MAINTAIN THE IMAGE OF OUR COUNTRY AS AN OPEN, DEMOCRATIC SOCIETY THAT DOES NOT CONCEAL ITS BUSINESS BEHIND FORBIDDING BARRIERS. HOWEVER, IT IS RECOGNIZED THAT THERE IS SOME DETERRENT VALUE IN THE VISIBILITY OF SOME SECURITY MEASURES. THESE TWO OPPOSING GOALS MUST BE RECONCILED IN ANY CONCEPT
- THE FACILITIES FOR THE GUARD FORCE SHALL BE PROTECTED AGAINST SMALL ARMS FIRE TO LEVEL IV (UL 752). THE FACILITIES SHALL ALSO BE SURROUNDED WITH STATIC BARRIERS SUCH AS CONCRETE PLANTERS AND GUARD POSTS TO PROTECT THE GUARDS FROM VEHICLES
- VEHICLE BARRICADES SHALL ALWAYS BE CONTROLLED MANUALLY BY THE GUARDS AT BOTH THE TRAFFIC CHECK POST AND VISITOR CONTROL CENTER. AUTOMATIC DEVICES SHALL BE USED TO SOUND AN ALARM AT THESE SAME LOCATIONS. IF THE THREAT IS SUFFICIENT, THE GUARDS MAY BE GIVEN THE OPTION OF USING THE AUTOMATIC DEVICES TO ACTIVATE THE BARRICADES; HOWEVER, ALL AUTOMATIC DEVICES WILL GIVE FALSE ALARMS AND SHOULD ONLY BE USED TO AUTOMATICALLY ACTIVATE THE BARRICADES UNDER THE MOST THREATENING CONDITIONS

## INDEX OF DRAWINGS



| Symbol | description | Date | Approved |
|---|---|---|---|

Revisions

BLACK & VEATCH ENGINEERS-ARCHITECTS

DEPARTMENT OF THE ARMY

Site code: A/E:

ACCESS POINTS FOR U. S. ARMY INSTALLATIONS

CONCEPTS A & B

| | | | |
|---|---|---|---|
| Dsn. by: K.L.L. | Chd by: W.F.W. | | |
| Reviewed by: | Date: JUNE 7, 1985 | Sheet reference number: | Design file no. |
| Approved by: | Drawing code: DEF 872-50-01 | - | Sheet 1 of 12 |

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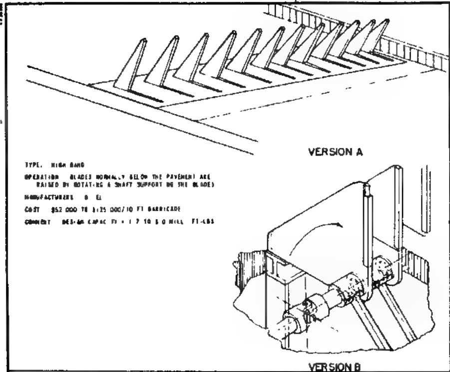


VB-2 BLADE BARRICADE
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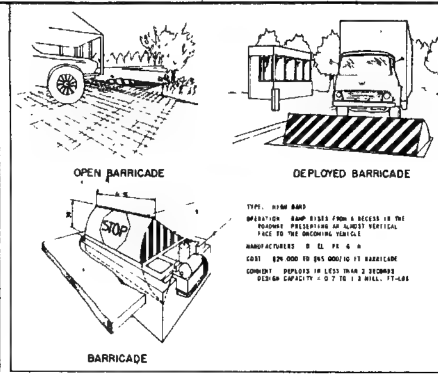


VB-3 RAMP BARRICADE
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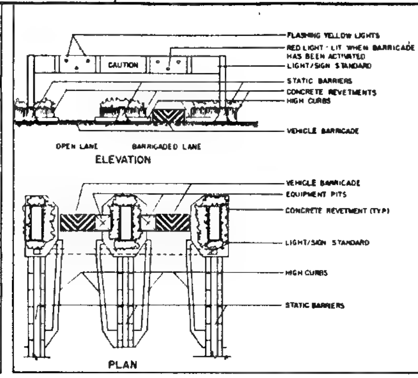
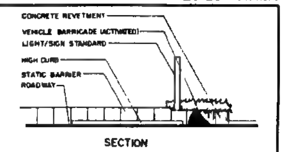


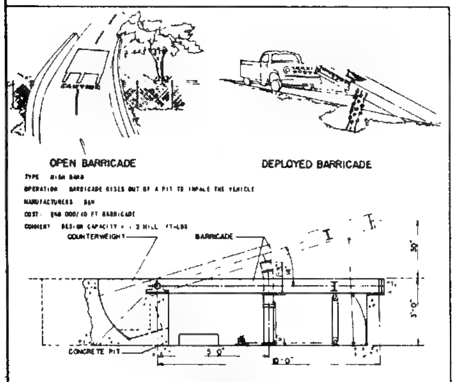




SECTION

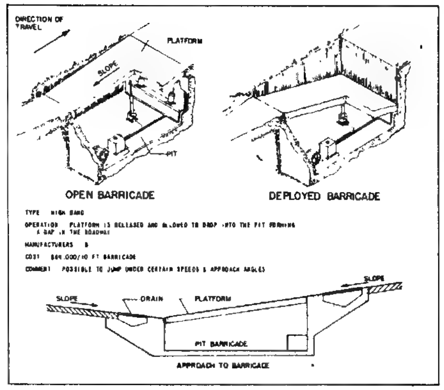
NOTES

1. STATIC BARRIERS ARE REQUIRED TO PREVENT THE THREAT FROM GOING AROUND THE BARRICADES
2. HIGH OR BARRIER CURBS AND CONCRETE REVETMENTS OR PLANTERS SHOULD BE USED TO NARROW THE ROADWAY AT THESE BARRICADES AND TO SLOW DOWN VEHICLES AS THEY APPROACH THE BARRICADES
3. WARNING LIGHTS AND SIGNS SHOULD BE USED TO CAUTION DRIVERS ABOUT THE LOCATION OF THE BARRICADES. SIRENS, HORNS AND GONGS MAY BE USED TO INDICATE DEPLOYMENT
4. LOCATE OPERATING EQUIPMENT, HYDRAULIC PUMPS, AIR COMPRESSORS, ETC., IN A PROTECTED LOCATION NEAR THE BARRICADES
5. DRAINAGE FOR THE PITS OF BARRICADES SHALL BE PROVIDED
6. HEATING EQUIPMENT MAY BE REQUIRED IN SOME CLIMATES
7. BARRICADE WIDTH MAY BE ADJUSTED TO MEET THE THREAT AND TO VARY THE COST OF THE BARRICADE
8. THESE BARRICADES MAY REQUIRE HEATERS OR OTHER TYPES OF WEATHER PROTECTION FOR PROPER OPERATION IN SOME CLIMATES

VB-1 GENERAL CONCEPT
SCALE 1"=20'




VB-4 POP-UP BARRICADE
SCALE NONE




VB-5 PIT BARRICADE
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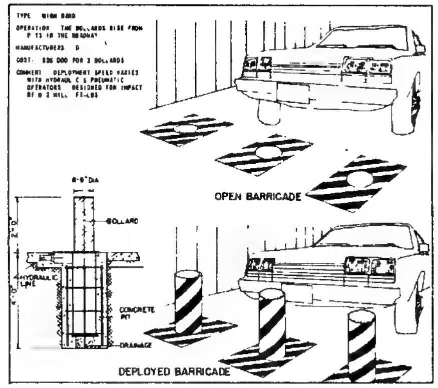



VB-6 BOLLARDS
SCALE NONE

## VEHICLE BARRICADES

**REFERENCE MATERIAL**

US ARMY FIELD CIRCULAR 19-112
USE OF BARRIERS IN COUNTERING TERRORIST SITUATIONS

DEPT OF ENERGY SAND 77-0777
BARRIER TECHNOLOGY HANDBOOK

**RELATED DRAWINGS**

DEF 872-10-01 DRAWING WEAPONS STORAGE AREA FENCE DETAILS & DRAIN BERM

**VEHICLE BARRICADES**

VEHICLE BARRICADES ARE ACTIVE BARRIERS USED TO CONTROL ACCESS THROUGH A GATE OR ENTRANCE. VEHICLE BARRICADES MAY BE GROUPED INTO THREE SUBGROUPS IDENTIFIED AS LOW BAND, MEDIUM BAND AND HIGH BAND ACCORDING TO THEIR DEGREE OF EFFECTIVENESS.

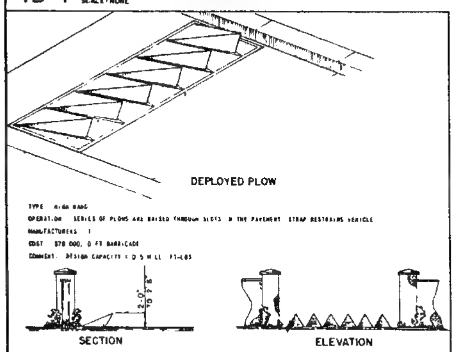
- LOW BAND ACTIVE BARRIERS ARE EFFECTIVE AGAINST PERSONNEL BUT HAVE VERY LIMITED EFFECTIVENESS AGAINST VEHICLES
- MEDIUM BAND ACTIVE BARRIERS PROVIDE ADDITIONAL RESISTANCE AGAINST VEHICLES. THEY WILL RESTRAIN SMALL, SLOW MOVING VEHICLES
- HIGH BAND ACTIVE BARRIERS, REFERRED TO AS BARRICADES, ARE THE MOST EFFECTIVE ACTIVE BARRIERS

CAUTION: THE FORCE OF ANY VEHICLE RAMMING THESE BARRICADES AT SPEEDS ABOVE 20 MPH MAY BE LETHAL TO THE OCCUPANTS OF THAT VEHICLE. THEREFORE EXTREME CAUTION MUST BE EXERCISED TO ENSURE THAT THEY ARE NOT ACTIVATED AT THE WRONG TIME. THE USE OF AUTOMATIC CONTROLS SHOULD BE AVOIDED SINCE A FALSE ALARM COULD HAVE DEADLY CONSEQUENCES

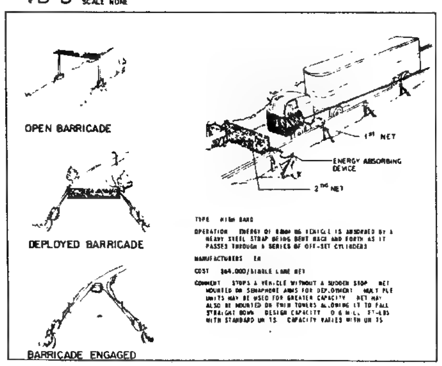
FOR LEGEND OF MANUFACTURERS, DESIGN PARAMETERS AND BARRICADE SELECTION CRITERIA SEE SHEET 10

**BARRICADE COSTS**

PRICES ARE BUDGET PRICES AS PER AR 415-? US MG 1985 PRICES AND LIST PRICE QUOTES FROM MANUFACTURERS. PRICES INCLUDE AN ALLOWANCE FOR FOUNDATIONS AND INSTALLATION. THEY DO NOT INCLUDE CONTROLS AND SITE UTILITIES. PRICES FOR BARRICADES ARE FOR WIDTHS STATED. THE COST OF SOME BARRICADES MAY BE REDUCED BY REDUCING THE WIDTH OF THE BARRICADES. HOWEVER, THE BARRICADES MUST NOT BE REDUCED IN WIDTH IF THE THREAT COULD THEN BYPASS THE NARROWER BARRICADES




VB-7 PLOW BARRICADE
SCALE NONE




VB-8 NET BARRICADE
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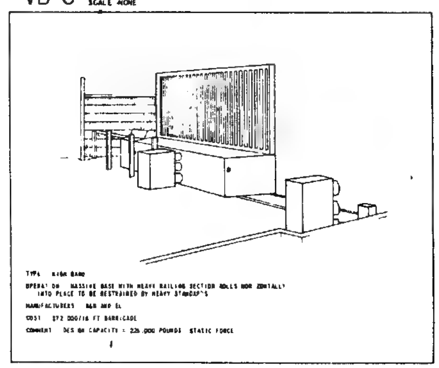

VB-9 ANTI-CRASH GATE
SCALE NONE

| Symbol | Description | Date | Approved |
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| | Revisions | | |

BLACK & VEATCH ENGINEERS-ARCHITECTS KANSAS CITY, MISSOURI

DEPARTMENT OF THE ARMY

ACCESS POINTS FOR US ARMY INSTALLATIONS

VEHICLE BARRICADES I

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| Dsn. by: KRL | Ckd by: WFW | | |
| Reviewed by: | Date: JUNE 7 1985 | Sheet reference number: | Design file no: |
| Approved by: | Drawing code: DEF 872-50-01 | – | Sheet 9 of 12 |



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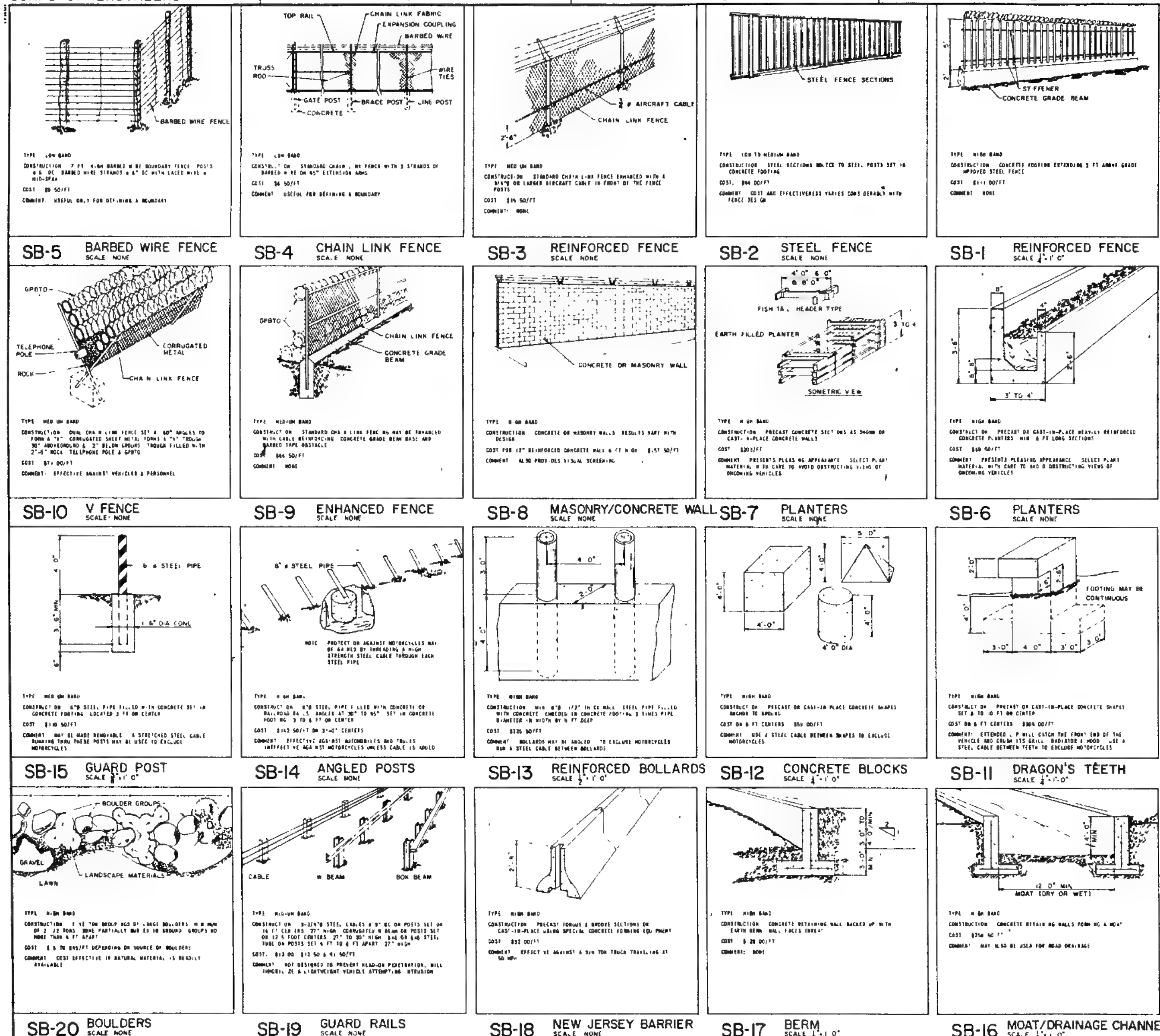
CORPS OF ENGINEERS | U. S. ARMY




## STATIC BARRIERS

**REFERENCE MATERIAL**

U.S. ARMY FIELD CIRCULAR 19-112
USE OF BARRIERS IN COUNTERING TERRORISM SITUATIONS

U.S. NAVY NAVFAC DM 18.1
PHYSICAL SECURITY

DEPT. OF ENERGY SAND 77-0777
BARRIER TECHNOLOGY HANDBOOK

**RELATED DRAWINGS**

NO. 6-00 — DRAWING FENCES AND DETAILS

DEF 872-D-01 DRAWING WEAPONS STORAGE AREA FENCE DETAILS AND CRASH BEAM

**STATIC BARRIERS**

VEHICLE BARRIERS MAY BE CATEGORIZED AS STATIC AND ACTIVE BARRIERS. STATIC BARRIERS ARE THOSE THAT ARE PLACED AND REMAIN IN PLACE UNTIL THEY ARE NO LONGER REQUIRED. ACTIVE BARRIERS ARE THOSE DEVICES USED TO CONTROL ACCESS THROUGH A GATE OR ENTRANCE. STATIC BARRIERS ARE USED TO CHANNEL THE FLOW OF TRAFFIC OR TO PREVENT VEHICLES FROM TAKING AN UNACCEPTABLE ROUTE AT ACCESS POINTS. ACTIVE BARRIERS ARE USED TO DENY PASSAGE ALONG ROADS AND ARE CALLED VEHICLE BARRICADES.

**CLASSES OF STATIC BARRIERS**

FC 19-112 GROUPS BARRIERS INTO THREE SUBGROUPS IDENTIFIED AS LOW BAND, MEDIUM BAND AND HIGH BAND ACCORDING TO THE DEGREE OF EFFECTIVENESS.

- LOW BAND STATIC BARRIERS ARE EFFECTIVE AGAINST PERSONNEL, BUT HAVE VERY LIMITED EFFECTIVENESS AGAINST VEHICLES. THEY ARE USEFUL FOR DEFINING PROPERTY LINES AND LIMITS OF TRAVEL.
- MEDIUM BAND STATIC BARRIERS ARE MORE EFFECTIVE AGAINST VEHICLES THAN THE LOW BAND BARRIERS. THEY ARE EFFECTIVE AGAINST SLOW MOVING SMALL WHEELED VEHICLES. SOME, BUT NOT ALL, ARE EFFECTIVE AGAINST MOTORCYCLES.
- HIGH BAND STATIC BARRIERS ARE THE MOST EFFECTIVE BARRIERS USED TO STOP MOVING VEHICLES. EVEN THESE BARRIERS VARY IN THEIR EFFECTIVENESS. ALL OF THEM WILL STOP SMALL WHEELED VEHICLES, HOWEVER NOT ALL WILL STOP HEAVY VEHICLES TRAVELING AT HIGH RATES OF SPEED WITHOUT BEING SEVERELY DAMAGED.

**SELECTION OF STATIC BARRIERS**

IN THESE CONCEPTS, BARRIERS SUCH AS GUARD POSTS (BOTH VERTICAL AND ANGLED), BOLLARDS, CONCRETE SHAPES SET IN STRATEGIC LOCATIONS, DITCHES OR MOATS, CONCRETE WALLS, EARTH-FILLED BARRIERS, AND THE NEW JERSEY HIGHWAY BARRIERS HAVE BEEN ENVISIONED. HOWEVER, SPECIFIC STATIC BARRIERS HAVE NOT BEEN IDENTIFIED. THE SELECTION OF A SPECIFIC BARRIER IS LEFT TO THE LOCAL SECURITY PLANNERS. SELECT BARRIERS BASED ON THE THREAT IDENTIFIED, THE TERRAIN ENCOUNTERED, THE VISUAL APPEARANCE DESIRED, AND THE BUDGET FOR THE BARRIERS. ALSO CONSIDER MAINTENANCE COSTS INCLUDING THE REMOVAL OF PLANT GROWTH, TRASH AND SNOW, REPAIR OR REPLACEMENT COSTS WHEN THE BARRIER IS BREACHED, THE EASE OF RELOCATING THE BARRIER, AND THE HAZARD PRESENTED TO INNOCENT PERSONNEL WHO MAY ACCIDENTALLY STRIKE THE BARRIER.

**ADDITIONAL NOTES**

APPEARANCE SHALL BE A MAJOR CONSIDERATION WHEN SELECTING STATIC BARRIERS.

THE INSTALLATION OF BARRIERS AROUND A SITE WILL NOT PREVENT PENETRATION OF THE SITE BY UNAUTHORIZED PERSONNEL. GIVEN TIME, ANY OF THESE BARRIERS MAY BE PENETRATED. THE BARRIERS DO PREVENT EASY MOBILE ACCESS FROM BOTH OUTSIDE AND INSIDE, DO DELAY BREACHING, AND DO DEMONSTRATE AN ADVERSARY'S INTENT. PLACING BARRIERS NEAR THE OUTSIDE PERIMETER FORCES THE ADVERSARY TO HAND CARRY HIS WEAPONS TO HIS TARGET.

THESE STATIC BARRIERS ARE TO BE USED AT THE MAIN ACCESS POINTS. MANY WILL NOT EXCLUDE PERSONNEL ON FOOT OR ON MOTORCYCLES. IF THESE BARRIERS ARE UNDER THE OBSERVATION OF GUARD PERSONNEL, PROTECTION AGAINST MOTORCYCLES AND PEDESTRIANS MAY NOT BE NECESSARY. OTHERWISE THOSE BARRIERS SHOULD BE SUPPLEMENTED TO EXCLUDE THESE THREATS.

IN ADDITION TO THE PROBLEMS OF PLANT GROWTH, WINDBLOWN TRASH, AND SNOW, DETECTION SENSOR LOCATIONS AND VIDEO ASSESSMENT POSITIONS MUST BE CONSIDERED WHEN ADDING STATIC BARRIERS TO A SITE. ALSO, STATIC BARRIERS MAY BE USED BY AN ADVERSARY FOR FIRING POSITIONS OR CONCEALMENT.

GROWTH CHARACTERISTICS OF PLANTS USED IN PLANTERS MUST BE CONSIDERED TO AVOID OBSTRUCTING THE GUARDS VIEWS OF ONCOMING TRAFFIC.

**PRICING NOTES**

PRICES ARE BUDGET PRICES AS PER AR 415-17 USING 1985 PRICES AND LIST PRICE QUOTES FROM MANUFACTURERS. PRICES FOR STATIC BARRIERS ARE GENERALLY PER FOOT OF BARRIER. THE PRICES INCLUDE AN ALLOWANCE FOR FOUNDATIONS AND INSTALLATION.

| Symbol | Description | Date | Approved |
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Revisions

BLACK & VEATCH
ENGINEERS-ARCHITECTS

DEPARTMENT OF THE ARMY

ACCESS POINTS
FOR
U. S. ARMY INSTALLATIONS

STATIC BARRIERS

Dwn by: CJR | Ckd by: WFB
Reviewed by:
Approved by:
Date: JUNE 7, 1985
Drawing code: DEF 872 50 01
Sheet reference number: –
Design file no.:
Rev.
Sheet 8 of 12

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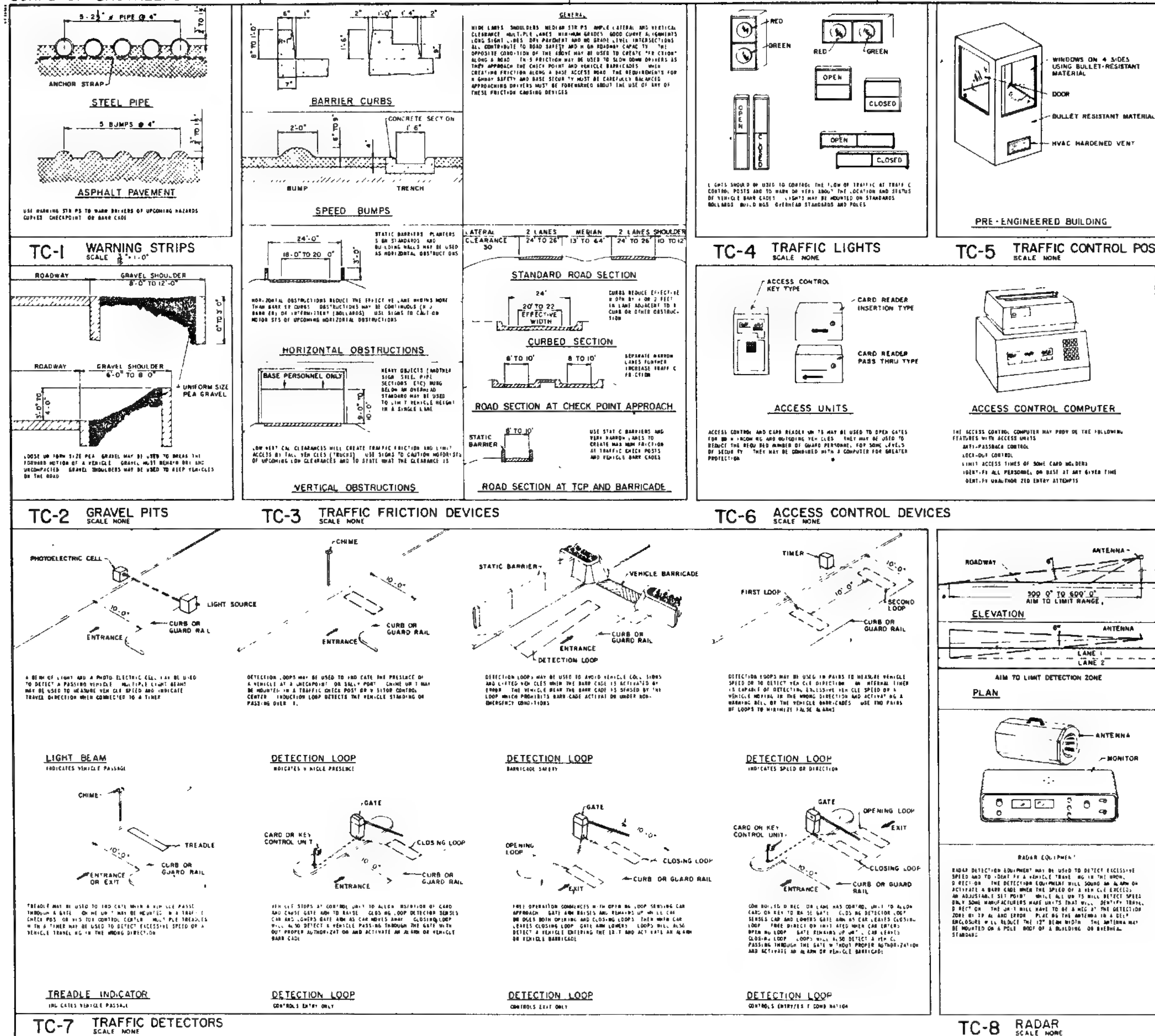
CORPS OF ENGINEERS

U. S. ARMY




## TRAFFIC CONTROL DEVICES

TRAFFIC CONTROL DEVICES INCLUDE THE FOLLOWING

1. WARNING DEVICES TO NOTIFY DRIVERS ABOUT THE TRAFFIC CHECKPOINT, VEHICLE BARRICADES, SPEED RESTRICTIONS, SHARP CURVES, AND OTHER ROAD HAZARDS
2. TRAFFIC FRICTION DEVICES USED TO MAKE THE DRIVERS REDUCE THEIR SPEED
3. SIGNS AND LIGHTS USED TO CONTROL THE FLOW OF TRAFFIC
4. TOLL GATES USED TO CONTROL THE FLOW OF TRAFFIC, TO DETERMINE THE STOPPING POSITION OF VEHICLES, AND TO IDENTIFY VEHICLES VIOLATING THE ACCESS POINTS
5. DEVICES USED TO INDICATE THE PRESENCE, DIRECTION, AND/OR SPEED OF A VEHICLE
6. ACCESS CONTROL DEVICES USED TO CONTROL THE OPERATION OF TOLL GATES
7. LIGHTING USED AT NIGHT TO ILLUMINATE THE CHECKPOINT AND PERSONS AND VEHICLES TRYING TO GAIN ACCESS AND TO BLIND UNAUTHORIZED PERSONS TRYING TO FORCE THEIR WAY THROUGH THE CHECKPOINT
8. FLASHING LIGHTS, SIRENS, HORNS, AND GONGS USED TO IDENTIFY WHEN A VEHICLE VIOLATES THE APPROACH CONDITIONS

ACCESS CONTROL COMPUTER

SMALL COMPUTERS USED TO CONTROL ACCESS TO PARKING LOTS ARE READILY AVAILABLE. KEYS, CARDS, AND CYPHERS MAY BE ISSUED TO BASE PERSONNEL AND MAY BE USED TO GAIN ACCESS THROUGH AN AUTOMATIC GATE. WHEN CARDS ARE USED, THE SYSTEM CAN BE PROGRAMMED TO LIMIT THE DAYS AND/OR HOURS THAT THE CARD HOLDER MAY BE GRANTED ACCESS. THE SYSTEM CAN LIMIT THE NUMBER OF TIMES A CARD HOLDER MAY GAIN ACCESS. CARD READERS IN THE EXIT LANES, FINGERPRINT READERS, AND OTHER IDENTIFICATION DEVICES MAY BE USED TO INCREASE THE LEVEL OF SECURITY. A PRINTER MAY BE USED TO LIST THE NAMES OF PERSONS ENTERING THE BASE OR THE UNAUTHORIZED ATTEMPTS REFUSED BY THE SYSTEM.

BARRICADE CONTROL

THE GUARDS AT THE CHECKPOINTS SHOULD ALWAYS HAVE MANUAL CONTROL OVER THE BARRICADES. THE CONCEPTS ALL SHOW MULTIPLE GUARD POSTS. EACH GUARD POST SHOULD HAVE CONTROL OVER ALL OF THE BARRICADES.

MOST OF THE BARRICADES MAY BE CONTROLLED BY AUTOMATIC MEANS SUCH AS DETECTION LOOPS AND RADAR. HOWEVER, AUTOMATIC CONTROLS SHOULD ONLY BE USED DURING HIGH SECURITY ALERT PERIODS DUE TO THE FREQUENCY OF FALSE ALARMS AND THE HAZARDS AND INCONVENIENCES ASSOCIATED WITH THE DEPLOYMENT OF THE BARRICADES.

FOOT SWITCHES MAY BE USED TO CONTROL THE BARRICADES. FOOT SWITCHES WILL ALLOW THE GUARDS TO USE BOTH HANDS TO HANDLE THEIR WEAPONS.

FLASHING LIGHTS, SIRENS, HORNS, GONGS, ETC. MAY BE USED TO WARN GUARDS THAT A VEHICLE IS VIOLATING THE APPROACH CONDITIONS AND THAT THEY SHOULD DEPLOY THE BARRICADES. THESE SAME DEVICES WILL USUALLY CAUSE THE INADVERTENT VIOLATOR TO COME TO AN IMMEDIATE PAUSE.

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Revisions

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ENGINEERS-ARCHITECTS
KANSAS CITY, MISSOURI

DEPARTMENT OF THE ARMY

ACCESS POINTS FOR U. S. ARMY INSTALLATIONS

# TRAFFIC CONTROL DEVICES

Date JUNE 7 1985

Drawing code DEF 872 ...

Sheet 7 of 12

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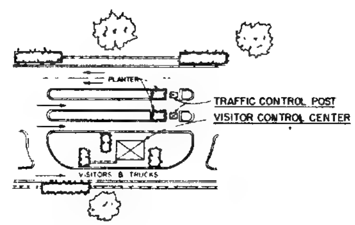
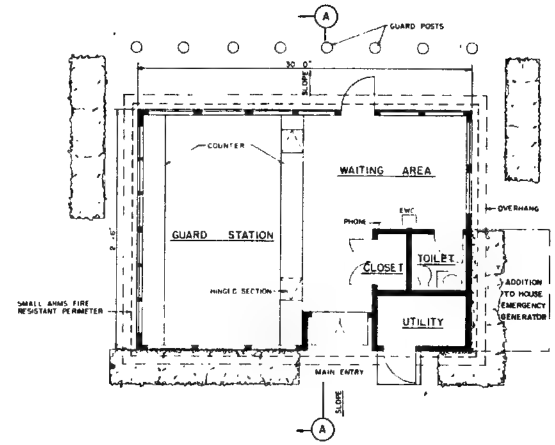
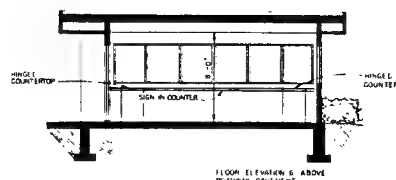



GENERAL FACILITY PLAN
SCALE 1"=50'




FLOOR PLAN
SCALE 1/4"=1'-0"




SECTION A-A
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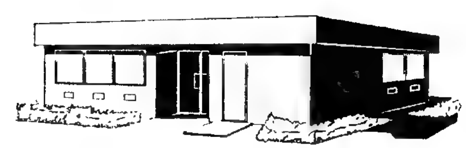


NOTE: THIS SKETCH IS NOT INTENDED TO ESTABLISH ARCHITECTURE DESIGN TREATMENT NOR USE OF SPECIFIC MATERIAL

PERSPECTIVE

ARCHITECTURAL

1. THE PERSPECTIVE INDICATED IS NOT INTENDED TO ESTABLISH ARCHITECTURAL DESIGN TREATMENT OR ARCHITECTURAL STYLE. WHERE POSSIBLE, USE OF LOCAL MATERIALS IS DESIRED, BUT IT IS NOT INTENDED THAT EXTREME DESIGN OR UNTRIED MATERIALS BE INCORPORATED. UNLESS NOTED TO THE CONTRARY, WINDOW AND DOOR LOCATIONS AND DIMENSIONS ARE APPROXIMATE AND SERVE AS A DESIGN GUIDE.
2. WALLS, DOORS, AND WINDOWS OF THE STRUCTURE'S SMALL ARMS FIRE-RESISTANT PERIMETER SHALL BE DESIGNED TO PROTECT PERSONNEL AGAINST SMALL ARMS FIRE. WALLS SHALL BE REINFORCED CONCRETE. DOORS SHALL BE STEEL PLATE AND WINDOWS SHALL BE BULLET-RESISTANT GLAZING AND FRAMES. SMALL ARMS FIRE SHALL BE DEFINED AS LEVEL IV AS DEFINED IN UL 752.
3. MINIMUM MATERIAL THICKNESS REQUIRED TO RESIST SMALL ARMS FIRE:

| | | |
|---|---|---|
| WALLS: REINFORCED CONCRETE | 5 IN | (12.7CM) |
| DOORS: ARMOR PLATE | 0.67 IN | (17MM) |
| DOORS: MILD STEEL | 1 IN | (25 MM) |
| WINDOWS: GLASS AND POLYCARBONATE RESIN SHEET LAMINATED | 1.38 IN | (35 MM) |

4. THE STRUCTURE'S INTERIOR SHALL CONSTITUTE A FIGHTING POSITION FOR SECURITY PERSONNEL. MANUALLY-OPERATED FIRING PORTS SHALL BE POSITIONED BELOW EACH EXTERIOR WINDOW AS SHOWN. WINDOW SILLS AND FIRING PORTS SHALL BE AT A HEIGHT TO PERMIT ALERT FORCE PERSONNEL TO FIRE FROM A KNEELING POSITION. UNLESS OTHERWISE NOTED, DOOR AND WINDOW LOCATIONS ARE APPROXIMATE AND SERVE AS A DESIGN GUIDE ONLY.
5. IF POWER GENERATOR EQUIPMENT IS REQUIRED, IT SHALL BE HOUSED IN A SPACE RESISTANT TO SMALL ARMS FIRE.
6. REFER TO SHEETS 11 AND 12 FOR THE REQUIREMENTS TO PROVIDE PROTECTIVE CONSTRUCTION AGAINST THE EFFECTS OF AN EXPLOSION AT THE VEHICLE BARRICADE.

STRUCTURAL

1. DIMENSIONS MAY BE ADJUSTED FOR STRUCTURE ADAPTATIONS. LIVE LOADS SHALL BE IN ACCORDANCE WITH TM 5-809-1.

PLUMBING

1. ALL PLUMBING SHALL BE IN ACCORDANCE WITH CURRENT TM 5-810-5 AND DOD 4270.1-M.

MECHANICAL

1. HEATING, VENTILATION, AND AIR CONDITIONING SHALL BE IN ACCORDANCE WITH CURRENT TM 5-810-1 AND DOD 4270.1-M.
2. VENTILATION SHALL BE PROVIDED AT THE RATE OF 1-1/2 AIR CHANGES OF FRESH AIR PER HOUR WHEN HEATING OR COOLING IS REQUIRED. A SEPARATE VENTILATION SYSTEM SHALL BE PROVIDED FOR 10 AIR CHANGES OF FRESH AIR PER HOUR IN ALL PERSONNEL AREAS. FRESH AIR INTAKES SHALL BE LOCATED IN OUTSIDE WALL IN A NON-VULNERABLE AREA.

ELECTRICAL

1. POWER SERVICE SHALL BE UNDERGROUND. THE NORMAL SOURCE OF ELECTRIC POWER SHALL BE BACKED UP WITH AN ALTERNATE SOURCE. A STAND-BY GENERATOR MUST BE EQUIPPED WITH SUITABLE MEANS FOR AUTOMATICALLY STARTING THE ENGINE UPON FAILURE OF THE NORMAL SOURCE OF ELECTRICAL SERVICE AND BE CAPABLE OF OPERATING ALL REQUIRED ELECTRICAL FUNCTIONS AFFECTING SECURITY, SAFETY, AND COMMUNICATIONS AT FULL POWER WITHIN 10 SECONDS OF FAILURE OF THE REGULAR SERVICE.
2. THE INTERIOR LIGHTING INTENSITIES SHOWN ARE AT WORKING LEVEL. ALL LIGHTING FIXTURES SHALL BE RAPID-START FLUORESCENT TYPE EXCEPT THAT INCANDESCENT TYPE SHALL BE USED IN THE TOILET AND UTILITY ROOMS. EMERGENCY LIGHTING (WITH BATTERY STANDBY) SHALL BE PROVIDED.
3. EXTERIOR LIGHTING SHALL PROVIDE A MINIMUM LEVEL OF 2.0 FOOTCANDLES HORIZONTAL ILLUMINATION MEASURED 6 INCHES ABOVE GROUND LEVEL. THE AREA ILLUMINATED SHALL BE NOT LESS THAN 100 FEET OUTWARD FROM THE VISITOR CONTROL CENTER AND SHALL EXTEND 25 FEET TO EITHER SIDE OF THE ROAD OR WALKWAY. THE AREA AROUND THE BUILDING EXTENDING 10 FEET OUTWARD ALSO SHALL BE ILLUMINATED. EXTERIOR LIGHTING CONTROLS SHALL BE LOCATED IN THE VISITOR CONTROL CENTER. USE RAPID RESTRIKE TYPE FIXTURES.
4. ELECTRICAL CONTROLS FOR THE VEHICLE BARRICADES AND ANY GATES SHALL BE LOCATED IN BOTH THE TRAFFIC CONTROL POST AND THE VISITOR CONTROL CENTER.
5. LOCATION OF POWER AND CONVENIENCE OUTLETS SHALL BE SELECTED BY THE DESIGN AGENCY.

UTILITY REQUIREMENTS

| | | |
|---|---|---|
| WATER (GPM) | HOT | 10 |
| | COLD | 25 |
| | TOTAL | 35 |
| WATER (GPD) | TOTAL | 290 |
| SEWAGE (GPD) | TOTAL | 290 |

ELECTRICAL LOADS

| | |
|---|---|
| LIGHTING | 4.5 KW |
| POWER | 2.0 KW |
| HEATING | 10.9 KW |
| COOLING | 13.2 KW |

HEATING REQUIREMENTS

BTU REQUIRED AT OUTSIDE DESIGN TEMPERATURES OF +10°F: 65,500 BTU/HR

AIR CONDITIONING

DESIGN CONDITIONS:
OUTSIDE: 95°F DB, 68°F WB
INSIDE: 75°F DB, 50% RELATIVE HUMIDITY
COOLING LOAD: 3 3/4 TONS

VENTILATION (FILTERED FRESH AIR)

10 AIR CHANGES PER HOUR WHEN HEATING OR COOLING IS NOT REQUIRED
2 AIR CHANGES PER HOUR WHEN HEATING OR COOLING IS REQUIRED

DESIGN DATA & ANALYSIS

| ROOM | CLEAR HGT REQUIRED | MINIMUM SIZE: INTERIOR | MINIMUM SIZE: SQ FT | LIVE LOADS | ELECTRICAL: LIGHTING FC | MECHANICAL: SUPPLEMENTAL PLUMBING | MECHANICAL: VENTILATION | MECHANICAL: HEATING, AIR COND, ETC. CENTRAL TEMP | REMARKS AND ADDITIONAL REQUIREMENTS |
|---|---|---|---|---|---|---|---|---|---|
| GUARD STATION | 8'-0" | 14'-0" x 20'-0" | [illegible] | SEE NOTE | 50 | NONE | SEE NOTE | FOR PERSONNEL COMFORT SEE NOTE | PROVIDE 5J TABLE NIGHT LIGHTING (REG LIGHTS OR DIMMER CONTROL) |
| WAITING AREA | 8'-0" | 14'-0" x 8'-0" | [illegible] | | 30 | ELECTRIC WATER COOLER CW, CD | SEE NOTE | FOR PERSONNEL COMFORT SEE NOTE | CD CONNECTED DRAIN |
| TOILET | 8'-0" | 5'-0" x 5'-0" | AS REQ'D | | 30 | NONE | 10 AIR CHANGES PER HOUR | FOR PERSONNEL COMFORT SEE NOTE | |
| UTILITY ROOM | AS REQ'D | AS REQ'D | AS REQ'D | | 15 | FLOOR DRAIN, WATER HEATER, HOSE BIBB | | NONE | |

| Symbol | Description | Date | Approved |
|---|---|---|---|

Revisions

BLACK & VEATCH ENGINEERS-ARCHITECTS KANSAS CITY, MISSOURI

DEPARTMENT OF THE ARMY OFFICE OF THE CHIEF OF ENGINEERS MILITARY CONSTRUCTION - ENGINEERING DIVISION WASHINGTON, D.C.

Site: Gdoor A/E

ACCESS POINTS FOR U.S. ARMY INSTALLATIONS

VISITOR CONTROL CENTER

Dwn by: KRL | Ckd by: WFW

Reviewed by:

Approved by:

Date: JUNE 7, 1985

Drawing code: DEF 872 50 01

Sheet reference number: -

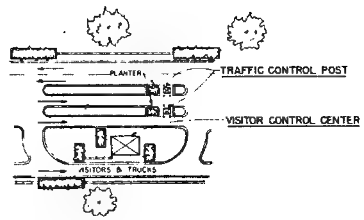
Design file no.:

Rev.:

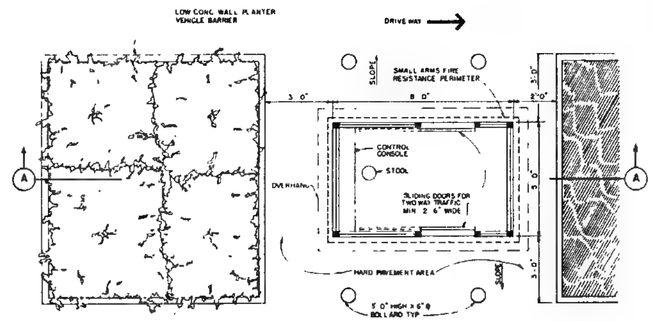
Sheet 6 of 12



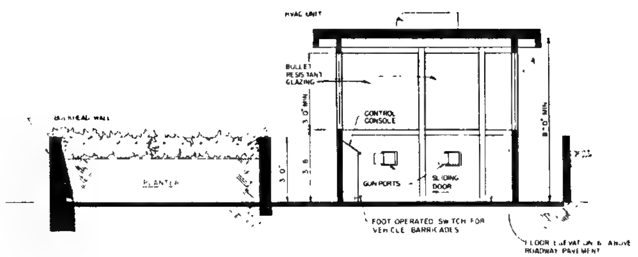
000685



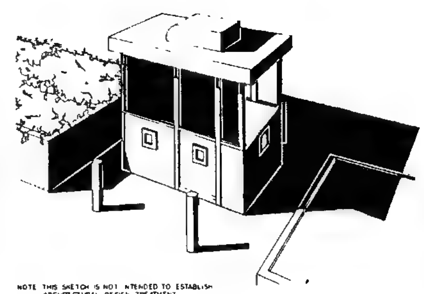

GENERAL FACILITY PLAN
SCALE 1" = 50'




FLOOR PLAN
SCALE 1/2" = 1'-0"




SECTION A-A
SCALE 1/2" = 1'-0"



NOTE THIS SKETCH IS NOT INTENDED TO ESTABLISH ARCHITECTURAL DESIGN TREATMENT

PERSPECTIVE

ARCHITECTURAL

1. CONSIDERATION WILL BE GIVEN TO A PRE-ENGINEERED INSULATED SMALL ARMS FIRE RESISTANT METAL BUILDING. SMALL ARMS FIRE RESISTANCE SHALL BE AS DEFINED BY UL 752 FOR HIGH POWERED RIFLE (CLASS IV) FIRE. REFER TO SHEET 6.
2. DOORS SHALL BE LOCATED SO SECURITY PERSONNEL MAY HAVE ACCESS FROM EITHER SIDE. CONTROL CONSOLE SHALL BE LOCATED SUCH THAT SECURITY PERSONNEL SHALL NOT BE IN A DIRECT LINE OF FIRE THRU EITHER DOOR WHEN DOORS ARE IN THE OPEN POSITION. CONTROL CONSOLE SHALL BE USED TO ENGAGE VEHICLE BARRICADES WHEN REQUIRED.
3. THE STRUCTURE'S INTERIOR SHALL CONSTITUTE A FIGHTING POSITION FOR SECURITY PERSONNEL. MANUALLY-OPERATED FIRING PORTS SHALL BE POSITIONED BELOW EACH EXTERIOR WINDOW AS SHOWN. WINDOW SILLS AND FIRING PORTS SHALL BE AT A HEIGHT TO PERMIT ALERT FORCE PERSONNEL TO FIRE FROM A KNEELING POSITION.
4. REFER TO SHEETS 11 AND 12 FOR THE REQUIREMENTS TO PROVIDE PROTECTIVE CONSTRUCTION AGAINST THE EFFECTS OF AN EXPLOSION AT THE VEHICLE BARRICADE.

STRUCTURAL

1. DIMENSIONS MAY BE ADJUSTED FOR STRUCTURE ADAPTATIONS. LIVE LOADS SHALL BE IN ACCORDANCE WITH TM 5-809-1.

PLUMBING

1. NONE REQUIRED

MECHANICAL

1. HEATING, VENTILATION, AND AIR CONDITIONING SHALL BE IN ACCORDANCE WITH CURRENT TM 5-810-1 AND DOD 4270.1-M.
2. VENTILATION SHALL BE PROVIDED AT THE RATE OF TWO AIR CHANGES OF FRESH AIR PER HOUR WHEN HEATING OR COOLING IS REQUIRED. FRESH AIR INTAKES SHALL BE LOCATED IN OUTSIDE WALL IN A NON-VULNERABLE AREA OR PROTECTED WITH SUITABLE BAFFLES.

ELECTRICAL

1. POWER SERVICE SHALL BE UNDERGROUND.
2. THE INTERIOR LIGHTING INTENSITIES SHOWN ARE AT WORKING LEVEL. ALL LIGHTING FIXTURES SHALL BE RAPID-START FLUORESCENT TYPE.
3. EXTERIOR LIGHTING SHALL PROVIDE A MINIMUM LEVEL OF 2.0 FOOTCANDLES HORIZONTAL ILLUMINATION MEASURED 6 INCHES ABOVE GROUND LEVEL. THE AREA ILLUMINATED SHALL BE NOT LESS THAN 100 FEET OUTWARD FROM THE CONTROL POST AND SHALL EXTEND 35 FEET TO EITHER SIDE OF THE ROAD OR WALKWAY. EXTERIOR LIGHTING CONTROLS SHALL BE LOCATED IN THE VISITOR CONTROL CENTER.
4. ELECTRICAL CONTROLS FOR THE VEHICLE BARRICADES AND ANY GATES SHALL BE LOCATED IN BOTH THE TRAFFIC CONTROL POST AND THE VISITOR CONTROL CENTER.
5. LOCATION OF POWER AND CONVENIENCE OUTLETS SHALL BE SELECTED BY THE DESIGN AGENCY.
6. FOOT OPERATED SWITCHES MAY BE USED TO OPERATE VEHICLE BARRICADES.
7. PROVIDE TELEPHONE & ALARM SERVICES.

UTILITY REQUIREMENTS

| | |
|---|---|
| WATER (GPM) | NONE REQUIRED |
| SEWAGE (GPD) | NONE REQUIRED |

ELECTRICAL LOADS

| | |
|---|---|
| LIGHTING | 0.3 KW |
| POWER | 1.0 KW |
| HEATING | 1.0 KW |
| COOLING | 0.5 KW |

HEATING REQUIREMENTS

BTU REQUIRED AT OUTSIDE DESIGN TEMPERATURES OF +10°F — 3200 BTU/HR

AIR CONDITIONING

| | | |
|---|---|---|
| DESIGN CONDITIONS | | |
| OUTSIDE | 85°F DB | 68°F WB |
| INSIDE | 75°F DB | 50% RELATIVE HUMIDITY |
| COOLING LOAD | 1/4 TON | |

VENTILATION FILTERED FRESH AIR

2 AIR CHANGES PER HOUR WHEN HEATING OR COOLING IS REQUIRED

DESIGN DATA & ANALYSIS

| ROOM | CLEAR HGT REQUIRED | MINIMUM SIZE | | LIVE LOADS | ELECTRICAL | MECHANICAL | | | REMARKS AND ADDITIONAL REQUIREMENTS |
|---|---|---|---|---|---|---|---|---|---|
| | | INTERIOR | SQ FT | | LIGHTING F C | SUPPLEMENTAL PLUMBING | VENTILATION | HEATING, AIR COND ETC. CONTROL TEMP | |
| TRAFFIC CONTROL POST | 7' 6" MIN HEADROOM | 4' 6" x 7' 6" | 35 | SEE NOTES | 50 | NONE | 2 AIR CHANGES PER HOUR | AS REQ'D FOR PERSONNEL COMFORT | HEATING & COOLING BY A PACKAGE UNIT. PROVIDE SUITABLE NIGHT LIGHTING. RED LIGHTS OR DIMMER CONTROL. |

| Date | Description | Date | Approved |
|---|---|---|---|

BLACK & VEATCH ENGINEERS-ARCHITECTS KANSAS CITY MISSOURI

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
MILITARY CONSTRUCTION – ENGINEERING DIVISION
WASHINGTON, D.C.

Site adapt A/E

US Army Corps of Engineers

# ACCESS POINTS FOR U.S. ARMY INSTALLATIONS
# TRAFFIC CONTROL POST

| | | | |
|---|---|---|---|
| Dwn. by: KRL | Ckd by: WFW | Date: JUNE 7 1985 | Sheet reference number: – |
| Reviewed by: | Approved by: | Drawing code: DEF 872 50 0 | Design file no. / Rev. / Sheet 5 of 12 |

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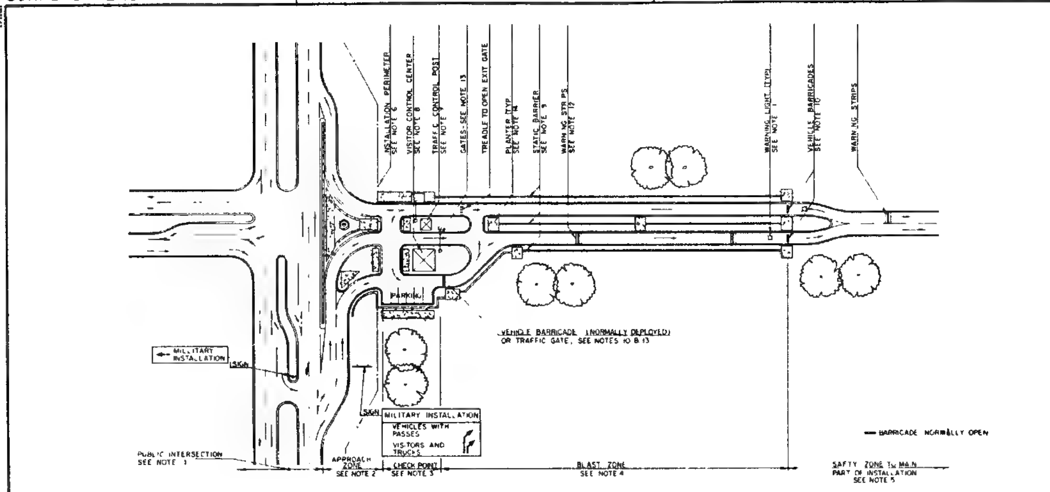
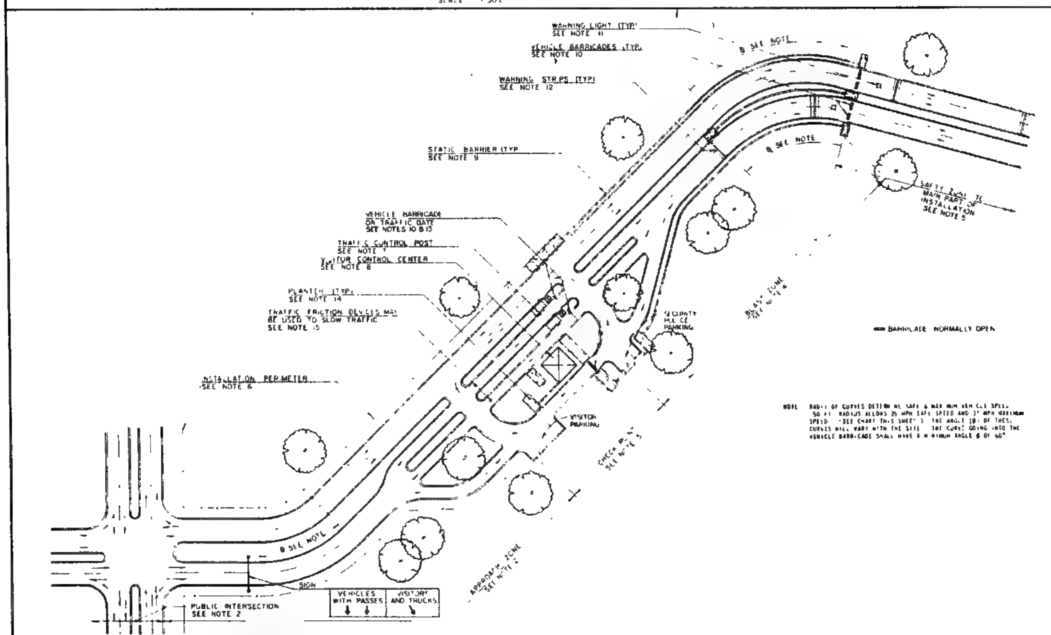
CORPS OF ENGINEERS | U. S. ARMY




1 CONCEPT G
SCALE 1"=500'




NOTE: RADII OF CURVES DETERMINE SAFE & MAXIMUM VEHICLE SPEED. 50 FT RADIUS ALLOWS 25 MPH SAFE SPEED AND 37 MPH MAXIMUM SPEED (SEE CHART THIS SHEET). THE ANGLE (θ) OF THESE CURVES WILL VARY WITH THE SITE. THE CURVE GOING INTO THE VEHICLE BARRICADE SHALL HAVE A MINIMUM ANGLE θ OF 60°

2 CONCEPT H
SCALE 1"=500'

## CONCEPT G

PREMISE: USE STATIC BARRIERS TO CREATE A SHARP TURN TO FORCE A VEHICLE TO SLOW DOWN BEFORE ENTERING THE CHECKPOINT.

OPERATION: VEHICLES WITH PASSES ARE SEPARATED FROM THOSE WITHOUT PASSES. GATES AT THE CHECKPOINT ARE OPTIONAL. VEHICLE BARRICADES ARE DEPLOYED BY GUARDS OR WHEN A TOLL GATE IS BROKEN BY A SPEEDING VEHICLE. THE EXIT LANE GATE IS AUTOMATICALLY RAISED ON DEMAND FOR AN EXITING VEHICLE.

APPLICATION: THIS CONCEPT IS WELL SUITED TO A SITUATION WHERE THERE IS A SHORT DISTANCE BETWEEN THE PUBLIC ROAD AND THE CHECKPOINT. THE BLAST ZONE MAY BE REDUCED IN LENGTH IF SALLY PORTS ARE FORMED IN EACH LANE BY ADDING ADDITIONAL BARRICADES AND THE GUARDS ARE PROTECTED FROM A BLAST.

LIMITATIONS: THE BARRIER AT THE PUBLIC ROAD LIMITS FLEXIBILITY FOR ENTERING AND EXITING THE INSTALLATION.

SEE SHEETS 1-4 FOR ADDITIONAL NOTES

## CONCEPT H

PREMISE: USE CURVES TO SLOW TRAFFIC BEFORE REACHING THE CHECKPOINT AND BEFORE REACHING THE VEHICLE BARRICADES.

OPERATION: TRAFFIC IS SLOWED BEFORE REACHING THE CHECKPOINT SO THAT GUARDS HAVE TIME TO IDENTIFY A THREATENING VEHICLE AND DEPLOY THE VEHICLE BARRICADES. THE CURVE AT THE VEHICLE BARRICADES AND THE STATIC BARRIER WHICH PREVENTS CROSSING OVER BETWEEN EXIT AND ENTRANCE LANES MINIMIZE THE THREATENING VEHICLE'S IMPACT SPEED AT THE BARRICADE.

APPLICATION: THIS CONCEPT REQUIRES A RELATIVELY LONG DISTANCE BETWEEN THE PUBLIC ROAD AND THE CHECKPOINT. IT REQUIRES A SIMILAR DISTANCE BETWEEN THE CHECKPOINT AND THE MAIN BASE.

LIMITATIONS: THE CONCEPT USES A FAIRLY LARGE LAND AREA.

SEE SHEETS 1-4 FOR ADDITIONAL NOTES

## VEHICLE APPROACH

VEHICLE APPROACH

THERE ARE SIGNIFICANT ADVANTAGES TO BE GAINED IN CONTROLLING THE SPEED OF THE APPROACHING VEHICLE. IF THE DESIGN VEHICLE IS NOT ALLOWED TO REACH THE BARRICADE TRAVELING AT A HIGH RATE OF SPEED, A MORE ECONOMICAL BARRICADE MAY BE USED AND THE PROBABILITY OF STOPPING THE VEHICLE ARE SIGNIFICANTLY INCREASED. IF A VEHICLE'S SPEED CAN BE REDUCED BY 50 PERCENT, THEN ITS KINETIC ENERGY IS REDUCED BY 75 PERCENT.

LAW-ABIDING DRIVERS WILL REDUCE THEIR SPEED WHEN APPROACHING THE CHECKPOINT IN RESPONSE TO WARNING STRIPS OR SPEED BUMPS IN THE ROAD, SPEED LIMIT, CAUTION, OR STOP SIGNS ALONGSIDE THE ROAD, FLASHING LIGHTS ALONG THE ROAD, OR CHANGES IN THE WIDTH OF THE ROAD OR ROAD SURFACE. HOWEVER, THESE MEASURES ARE NOT SUFFICIENT TO FORCE THE DETERMINED TERRORIST TO SLOW DOWN. MORE FORCEFUL WAYS TO MAKE THE DRIVER OF ANY VEHICLE SLOW DOWN INCLUDE THE USE OF HORIZONTAL AND VERTICAL CURVES IN THE ROAD, STRINGENT REDUCTIONS IN THE ROAD WIDTHS, AND TRAFFIC CONGESTION IN THE ROAD AHEAD. TO USE THESE MEASURES SUCCESSFULLY, IT IS NECESSARY TO KEEP THE DRIVER ON THE ROAD AND PREVENT HIM FROM GOING AROUND THESE HAZARDS OR TAKING A SHORT CUT ACROSS ANY OPEN TERRAIN. THE CONCEPTS SHOWN ON THESE DRAWINGS ILLUSTRATE WAYS TO ACHIEVE THIS REDUCTION IN APPROACH SPEEDS. TRAFFIC FRICTION DEVICES ARE SHOWN ON SHEET 7. THE TABLE BELOW MAY BE USED TO SELECT HORIZONTAL CURVES IN THE ROAD BEFORE THE CHECKPOINTS AND THE VEHICLE BARRICADES. THE CRITICAL R CURVES ARE NOT CALCULATED USING A SUPER-ELEVATION. IN ADDITION, IF THESE CURVES WERE GIVEN A REVERSE SUPER-ELEVATION, A SPEEDING VEHICLE WOULD MORE LIKELY SKID OUT OF CONTROL.

VERTICAL CURVES MAY BE EFFECTIVE IN CONTROLLING THE SPEED OF APPROACHING VEHICLES WHEN THE CHECKPOINT IS LOCATED AT THE TOP OF A STEEP GRADE. APPROACHING VEHICLES, ESPECIALLY HEAVY TRUCKS, CAN ONLY APPROACH THE CHECKPOINT AT REDUCED SPEEDS. FOR SIMILAR REASONS, THE CHECKPOINT SHOULD NOT BE LOCATED AT THE BOTTOM OF A HILL. HEAVY TRUCKS AND OTHER VEHICLES WILL BE MORE DIFFICULT TO STOP IF THEY ARE ABLE TO BUILD UP SPEED COMING DOWN A HILL.

WHEN SHARP HORIZONTAL CURVES, STEEP VERTICAL CURVES, AND/OR TRAFFIC FRICTION DEVICES ARE USED, SIGNS MUST BE POSTED TO WARN APPROACHING DRIVERS OF THE UPCOMING TRAFFIC HAZARDS AND TO ESTABLISH THE SAFE VEHICLE SPEEDS. SIGNS SHALL ALSO CAUTION THAT SPEED LIMITS WILL BE STRICTLY ENFORCED.

WHERE POSSIBLE, INCOMING DRIVERS SHOULD CURVE TO THE LEFT AS THEY APPROACH THE CHECKPOINT. LEFT-HAND CURVES GIVE THE GUARDS AT THE CHECKPOINT A BETTER VIEW OF INCOMING VEHICLES AND THEIR DRIVERS AND MAKES IT EASIER FOR THEM TO IDENTIFY WHICH VEHICLES ARE AUTHORIZED ENTRY. LEFT-HAND CURVES ALSO EXPOSE THE DRIVER OF A TERRORIST VEHICLE TO THE GUARDS' LINE OF FIRE AND ANY PASSENGERS OF SUCH A VEHICLE ARE FORCED TO FIRE PAST THE DRIVER OUT THE LEFT SIDE WINDOWS.

### APPROACH CURVES

| VEHICLE SPEED | TURNING RADIUS (R) RECOMMENDED | SAFE (R) | CRITICAL R |
|---|---|---|---|
| 15 MPH | 90 FT | 50 FT | 25 FT |
| 20 | 160 | 90 | 40 |
| 25 | 255 | 150 | 70 |
| 30 | 375 | 230 | 100 |
| 35 | 525 | 300 | 135 |
| 40 | 710 | 430 | 175 |
| 45 | 930 | 550 | 225 |
| 50 | 1180 | 690 | 275 |
| 55 | 1495 | 840 | 335 |
| 60 MPH | 1845 FT | 1040 FT | 400 FT |

USE OF TABLE

1. SELECT DESIRED VEHICLE SPEED
2. SELECT R BETWEEN RECOMMENDED R AND SAFE R
3. NOTE VEHICLE SPEED OF CRITICAL R CORRESPONDING TO R SELECTED IN STEP 2
4. IS VEHICLE SPEED FOUND IN STEP 3 ACCEPTABLE?
5. IF NOT, SELECT A SMOOTHER R AND REPEAT STEPS 3 & 4

CRITICAL R = $V^2$ ÷ 9.0
V = VEHICLE SPEED IN MPH

RECOMMENDED R BASED ON AASHO RECOMMENDATIONS FOUND IN HIGHWAY ENGINEERING, TABLE 8-10
SAFE R BASED ON GUIDE VALUES FOR EXIT RAMPS FOUND IN STANDARD HANDBOOK FOR CIVIL ENGINEERS, TABLE 16-24
CRITICAL R BASED ON A 0.6 COEFFICIENT OF SIDE FRICTION
APPROACH CURVES ASSUMED TO BE FLAT, I.E. NO SUPERELEVATION

| Symbol | Description | Date | Approved |
|---|---|---|---|
| | | | |

Revision

BLACK & VEATCH
ENGINEERS-ARCHITECTS
KANSAS CITY, MISSOURI

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
MILITARY CONSTRUCTION - ENGINEERING DIVISION
WASHINGTON, D.C.

Site adapt A/E

U.S. Army Corps of Engineers

# ACCESS POINTS FOR U. S. ARMY INSTALLATIONS

# CONCEPTS G & H

| | | | |
|---|---|---|---|
| Dsn. by: K.L. | Ckd. by: WFM | | |
| Reviewed by: | Date: JUNE 7 1985 | Sheet reference number: – | Design file no. |
| Approved by: | Drawing code: DEF 872 50 01 | | Rev. |
| | | | Sheet 4 of 12 |

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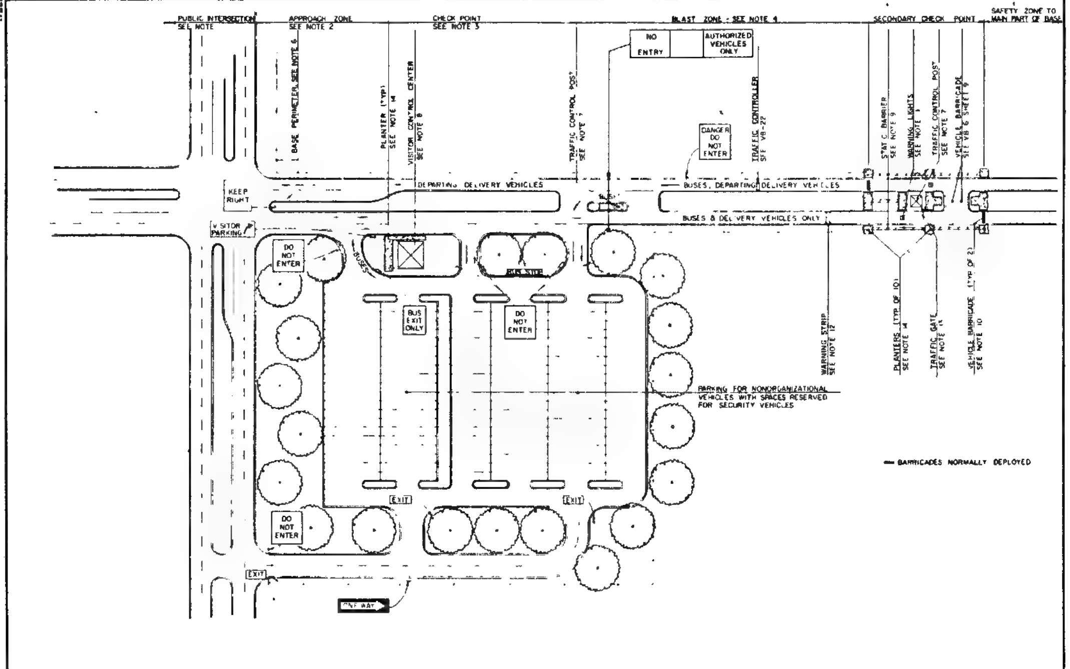



6 CONCEPT E
SCALE 1"=500'

CONCEPT E

PREMISE: REDUCE VEHICULAR ACCESS TO THE INSTALLATION TO SUCH A SMALL NUMBER OF VEHICLES THAT EACH ONE CAN BE STOPPED AND INSPECTED IN A SALLY PORT

OPERATION: STAFF AND VISITORS PARK THEIR PRIVATE VEHICLES OUTSIDE THE INSTALLATION PERIMETER AND TAKE SHUTTLE BUSES ONTO THE INSTALLATION. TO RIDE THE BUS, A PERSON MUST HAVE AN INSTALLATION ACCESS PASS. THE VEHICLES ALLOWED ON THE INSTALLATION CAN BE LIMITED TO SHUTTLE BUSES AND DELIVERY TRUCKS. OFFICIAL VEHICLES, VEHICLES DRIVEN BY THE HANDICAPPED, PRIVATE VEHICLES OWNED BY PERSONS LIVING ON THE INSTALLATION, CAR POOL VEHICLES AND VEHICLES ENTERING THE INSTALLATION AT TIMES OTHER THAN RUSH HOUR MIGHT ALSO BE ALLOWED ON THE INSTALLATION DEPENDING ON THE AMOUNT OF TRAFFIC, SEVERITY OF THE SECURITY THREAT, OR PRACTICALITY OF SHUTTLE BUS SERVICE. THE USE OF TOLL GATES AND CARD READERS TO ALLOW ACCESS TO PREAPPROVED VEHICLES IS AN OPTIONAL ADDITION TO THIS CONCEPT.

THE TWO VEHICULAR BARRICADES WHICH FORM THE SECONDARY CHECKPOINT ARE NORMALLY DEPLOYED

APPLICATION: THIS CONCEPT DOES NOT REQUIRE A LONG APPROACH ZONE BUT IT DOES REQUIRE SPACE FOR PARKING LOTS

LIMITATIONS: SHUTTLE BUS SERVICE MAY NOT BE FEASIBLE ECONOMICALLY PARTICULARLY AT A LARGE, SPRAWLING, EXISTING INSTALLATION. MINIMAL BLAST PROTECTION IS OFFERED TO SECURITY PERSONNEL AT SECONDARY CHECKPOINT

NOTE: VEHICLE BARRICADES MUST BE CAPABLE OF PREVENTING A TERRORIST FROM TAILGATING A VEHICLE AUTHORIZED ENTRY. IF THE BARRICADE SELECTED IS NOT CAPABLE OF PREVENTING TAILGATING, TWO BARRICADES SHOULD BE USED IN EACH ENTRY/EXIT LANE TO FORM A TRUE SALLY PORT

WHEN AN INSTALLATION REQUIRES A HIGH LEVEL OF SECURITY, THE BARRICADES SHOULD BE USED IN PAIRS TO FORM SALLY PORTS FOR EACH ENTRY/EXIT LANE

SEE SHEETS 1-4 FOR ADDITIONAL NOTES

## GENERAL NOTES (CONT)

20. OVERHEAD OBSTRUCTION - AN OVERHEAD OBSTRUCTION MAY BE USED TO SEPARATE TRUCKS FROM AUTOMOBILES BASED UPON THE AMOUNT OF HEADROOM EACH VEHICLE NEEDS TO PASS UNDER AN OBSTRUCTION. THIS OBSTRUCTION OR PORTAL MAY ALSO BE USED TO MOUNT SIGNS, TRAFFIC LIGHTS, AND ENTRY CONTROL EQUIPMENT

21. LANE CONTROL - THE VEHICLE BARRICADES MUST BE OPERATED IN ONE OF TWO METHODS. ALL FOUR BARRICADES MAY BE OPERATED TOGETHER IF A VEHICLE VIOLATES THE CHECKPOINT. THIS OPERATION WOULD PREVENT A TERRORIST FROM FORCING HIS WAY THROUGH THE EXIT LANES AND THEN AVOIDING THE VEHICLE BARRICADES IN THE EXIT LANES BY WEAVING TO THE LEFT TO SLIP BY THE BARRICADES IN THE ENTRY LANES. IF OPERABLE BOLLARDS OR A SIMILAR TYPE OF VEHICLE BARRICADE WERE USED TO PROVIDE A POSITIVE BARRIER TO KEEP VEHICLES FROM SWITCHING FROM EXIT TO ENTRY LANES, ONLY THE TWO VEHICLE BARRICADES ON THE VIOLATED SIDE WOULD HAVE TO BE ACTIVATED. THE POSITIVE BARRIER COULD ALSO BE A DETECTION DEVICE SUCH AS A LIGHT BEAM TO DETECT WHEN A VEHICLE CROSSES OVER. IN THAT EVENT THE SECOND SET OF BARRICADES WOULD HAVE TO BE ACTIVATED

22. TRAFFIC LIGHTS - THESE TRAFFIC LIGHTS MAY BE USED TO CONTROL THE FLOW OF TRAFFIC DURING RUSH HOURS INSTEAD OF THE BARRICADES. DURING RUSH HOUR TRAFFIC IT IS ASSUMED THAT THE VOLUME OF TRAFFIC WILL BE ADEQUATE TO PREVENT A TERRORIST FROM FORCING HIS WAY PAST LINES OF VEHICLES ON A NARROW ROAD

23. LANE DIVIDERS - ADDITIONAL STATIC BARRIERS MAY BE USED TO SEPARATE INDIVIDUAL LANES OF TRAFFIC. WHEN LANE DIVIDERS ARE USED, ONLY ONE VEHICLE BARRICADE WOULD HAVE TO BE ACTIVATED, THUS PERMITTING TRAFFIC TO FLOW IN ALL OTHER LANES. LANE DIVIDERS ALSO MAKE IT POSSIBLE TO CLOSE LANES DURING OFF HOURS WHEN THE TRAFFIC IS VERY LIGHT

24. WHEN VISITORS DENIED ADMISSION TO THE INSTALLATION MUST CROSS SEVERAL LANES OF INCOMING TRAFFIC, THEY WILL REQUIRE ASSISTANCE TO BE ABLE TO QUICKLY EXIT FROM THE ACCESS POINT, ESPECIALLY DURING RUSH HOUR TRAFFIC. THIS ASSISTANCE MAY BE PROVIDED IN SEVERAL WAYS:
   a. SECURITY PERSONNEL WORK TOGETHER TO PROPERLY DIRECT TRAFFIC
   b. TRAFFIC LIGHTS ARE USED TO STOP NORMAL TRAFFIC WHILE THE VISITOR LEAVES
   c. TRAFFIC GATES ARE USED TO STOP NORMAL TRAFFIC

25. SIRENS, AIR HORNS, FLASHING LIGHTS, ETC. SHOULD BE USED AS ALARM DEVICES WHEN AN ILLEGAL ENTRY IS DETECTED

## TRAFFIC VOLUME

THE FOLLOWING GUIDELINES MAY BE USED TO DETERMINE THE REQUIRED NUMBER OF ENTRY/EXIT LANES REQUIRED AT THE CHECKPOINTS

THE VOLUME OF TRAFFIC ON A ROAD IS AFFECTED BY THE TERRAIN, ROAD WIDTH, LOCATION OF OBSTRUCTIONS ALONG THE ROAD, AND THE PERCENTAGE OF TRUCKS IN THE TRAFFIC. WITH LEVEL TERRAIN AND 5% OF THE TRAFFIC BEING TRUCKS, THE FOLLOWING TRAFFIC VOLUMES MAY FLOW ALONG A ONE-WAY ROAD

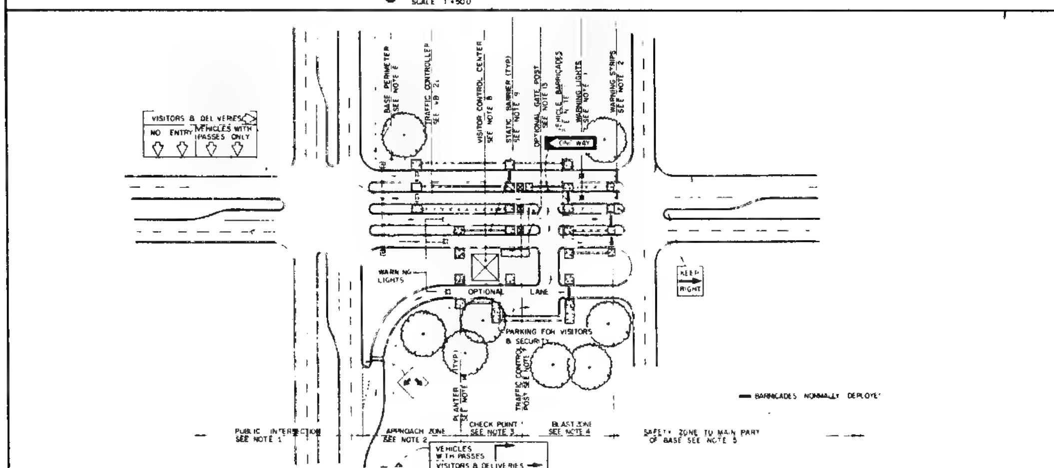
| | VEHICLES/HOUR |
|---|---|
| • 10 FT LANE WITH NO OBSTRUCTIONS WITHIN 6 FT OF THE EDGES OF THE ROADWAY | 1730 |
| • 10 FT LANE WITH OBSTRUCTIONS ON BOTH SIDES 4 FT FROM THE EDGES OF THE ROADWAY | 1690 |
| • 10 FT LANE WITH OBSTRUCTIONS ON BOTH SIDES 2 FT FROM THE EDGES OF THE ROADWAY | 1590 |
| • 10 FT LANE WITH OBSTRUCTIONS ON BOTH SIDES AT THE EDGES OF THE ROADWAY | 1400 |
| • 8 FT LANE WITH OBSTRUCTIONS ON BOTH SIDES AT THE EDGES OF THE ROADWAY | 1200 |

THE VOLUME OF TRAFFIC ACTUALLY PASSING A TCP WILL BE CONSIDERABLY REDUCED FROM THOSE VOLUMES LISTED ABOVE IF ANY TYPE OF SECURITY CHECK IS PERFORMED. ASSUMING LEVEL TERRAIN, NO TRUCKS, AND A 10 FT ROADWAY WITH OBSTRUCTIONS ON BOTH SIDES AT THE EDGES OF THE ROADWAY, THE FOLLOWING VOLUMES OF TRAFFIC MAY BE EXPECTED TO PASS A TCP IN ONE LANE OF TRAFFIC

| | VEHICLES/HOUR |
|---|---|
| • NO SECURITY CHECK | 1400 |
| • VEHICLE TAG CHECK | 1000-1200 |
| • PERSONNEL ID CHECK | 400-600 |
| • COMPLETE INSPECTION | LESS THAN 60 |

WITH TRAFFIC CONTROL DEVICES, THE FOLLOWING VOLUMES MAY BE EXPECTED

| | VEHICLES/HOUR |
|---|---|
| • TOLL GATE-FREE PASSAGE WITH GATE CLOSING AFTER EACH VEHICLE | 250 |
| • TOLL GATE & CARD READER | 150 |




7 CONCEPT F
SCALE 1"=50'-0"

CONCEPT F

PREMISE: INCREASE THE NUMBER OF INCOMING LANES AND TRAFFIC CONTROL POSTS SO THAT EACH VEHICLE CAN BE STOPPED AND INSPECTED

OPERATION: THE VEHICLE BARRICADE IN EACH ENTRANCE AND EXIT LANE MUST BE DEPLOYED AT ALL TIMES BECAUSE THERE WOULD NOT BE SUFFICIENT TIME FOR DEPLOYMENT AFTER IDENTIFICATION OF A THREAT. THE TOLL GATE IN EACH ENTRANCE LANE IS A SAFETY FEATURE THAT DEFINES THE STOPPING POINT FOR INSPECTION AND STOPS A VEHICLE BEFORE IT COLLIDES WITH THE BARRICADE. THE VEHICLE BARRICADES MAY BE OPENED TO PERMIT GREATER TRAFFIC FLOWS IF SECURITY CONDITIONS PERMIT IT

THE OPTIONAL SEPARATE LANE FOR INCOMING VISITORS AND TRUCKS IMPROVES THE EFFICIENT FLOW OF TRAFFIC THROUGH THE OTHER LANES

APPLICATION: THIS CONCEPT IS WELL SUITED TO INSTALLATIONS WITH MINIMAL DISTANCE BETWEEN THE PUBLIC ROAD AND THE CHECKPOINT

LIMITATIONS: THIS CONCEPT REQUIRES A LARGE NUMBER OF EXPENSIVE VEHICULAR BARRICADES WHICH ARE SUBJECT TO FREQUENT OPERATION (HEAVY WEAR AND TEAR). MINIMAL BLAST PROTECTION IS OFFERED TO SECURITY PERSONNEL

NOTE: VEHICLE BARRICADES MUST BE CAPABLE OF PREVENTING A TERRORIST FROM TAILGATING A VEHICLE AUTHORIZED ENTRY. IF THE BARRICADE SELECTED IS NOT CAPABLE OF PREVENTING TAILGATING, TWO BARRICADES SHOULD BE USED IN EACH ENTRY/EXIT LANE TO FORM A TRUE SALLY PORT

WHEN AN INSTALLATION REQUIRES A HIGH LEVEL OF SECURITY, THE BARRICADES SHOULD BE USED IN PAIRS TO FORM SALLY PORTS FOR EACH ENTRY/EXIT LANE

SEE SHEETS 1-4 FOR ADDITIONAL NOTE

| Sym | Description | Date | Approved |
|---|---|---|---|
| | | | |

Revisions

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Site adapt A/E

ACCESS POINTS FOR U. S. ARMY INSTALLATIONS

CONCEPTS E & F

| Dwn by: RDT | Ckd by: WFA | | |
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| Approved by: | Drawing code: DEF 872-5 | - | Sheet 3 of 12 |

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# ENERGY ABSORPTION PHENOMENA ASSOCIATED WITH STOPPING VEHICLES

by

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at the

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May 16, 1986

SOUTHWEST RESEARCH INSTITUTE
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ENERGY ABSORPTION PHENOMENA ASSOCIATED WITH STOPPING VEHICLES

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ABSTRACT

A large vehicle traveling at a high rate of speed represents a tremendous amount of energy that must be absorbed in stopping a vehicle. This energy must be dissipated through work done on the barrier and/or the vehicle structure. Work performed on the barrier can consist of deformation or displacement of the barrier and foundation. The vehicle structure can be deformed, crushed, or torn to absorb energy. The degree to which the kinetic energy is dissipated in the barrier or vehicle is determined by the relative stiffness of the two structures. In evaluating phenomena associated with stopping vehicles, three primary factors are considered: 1) vehicle mass, 2) impact speed, and 3) the height at which the vehicle interacts with the barrier. Development of each of these factors is presented. Basic design considerations for permanent barriers and gates are developed.

## I. Introduction

Security of installations in the United States and all over the world has become a major concern recently. A primary new threat is the car-bomb attack where a vehicle carrying explosives is driven up to a facility with the intention of creating as much damage and worldwide publicity as possible. This new form of attack has increased the vulnerability of all existing installations.

The most effective protection against this threat is to stop the vehicle before it reaches the targeted location. Because an attacker is potentially suicidal, normal traffic control practices are not sufficient to protect the target. Therefore, additional measures are required to stop the car-bomb vehicle and secure the installation.

To stop a vehicle, the kinetic energy, the capacity that a moving body has for doing work, must be absorbed. When all the energy has been absorbed, the vehicle is stopped. The phenomena of absorbing energy is a relatively simple concept when broken down into its basic terms. However, designing barriers to absorb the energy and stop an attacking vehicle is more complex, primarily because of the limitations of the car-bomb scenario. This paper defines kinetic energy and the components that affect its magnitude. Methods of controlling and absorbing the energy represented by a car-bomb vehicle are discussed and basic barrier design principles are presented.

## II. Kinetic Energy

A moving body has what engineers call kinetic energy. This is its capacity for doing work. The mathematical equation defining kinetic energy is:

$$KE = 1/2\ mv^2 \tag{1}$$

where

KE = kinetic energy (ft-lbs or Joules)

m = mass of the vehicle (the weight of the vehicle divided by gravity or m = weight/32.2 [lbs/(ft/sec$^2$)])

v = velocity, or speed, of the vehicle (ft/sec).

The kinetic energy of a large sedan which weighs 4000 pounds and is traveling at 55 mph represents enough energy to lift it over 100 feet straight up.

This energy would be absorbed through the braking of the vehicle under normal circumstances. When braking occurs, the kinetic energy is converted into heat energy, which is absorbed by the brakes. To stop a car-bomb vehicle, the kinetic energy must be absorbed or dissipated through work done on a barrier and/or the vehicle structure. This work may involve a change of velocity of the vehicle, a change of its relative position, a change of its shape, and/or a change of the position and shape of the barrier. Deformation, crushing and tearing of the vehicle and deformation and displacement of the

barrier, are the principal means of absorbing the kinetic energy of a car bomb vehicle.

The two factors that determine the amount of kinetic energy in a vehicle are its mass and its speed (velocity). A graph of relative kinetic energy for different speeds using a typical vehicle is given in Figure 1. This figure provides a graphic representation of the effect speed has on the energy of a moving body. As shown, when the speed doubles, the kinetic energy quadruples its value.

## III. Attainable Speeds

The maximum practical speed that a vehicle can obtain is determined by the vehicle properties and the terrain. These properties are summarized in Table 1.

TABLE 1. Physical Properties Affecting Vehicle Speed.

| Vehicle | Terrain |
|---|---|
| Engine size or horsepower | Grade |
| Transmission Efficiency | Surface Smoothness |
| Gross mass | Approach path length |
| Rolling Resistance Friction | Approach path alignment |
| Wind Resistance | |

The size and power of an attack vehicle are determined by the attacker and are unknown by those securing an installation prior to an attack. However, there are some practical limits that may be placed on the vehicle sizes. Because of the weight and volume of potential explosive cargo, most cars and small trucks are unlikely candidates. Alternately, very large vehicles such as tractor-trailers require long distances to accelerate to speeds necessary to penetrate even standard traffic barriers. Table 2 summarizes the attainable speeds and kinetic energies of several possible car-bomb vehicles for different lengths of approach paths.

The values in this table were calculated assuming that the terrain was flat and smooth and that the acceleration path was straight and the impact into a barrier was head-on. The vehicle engine was assumed to operate at the brake horsepower (BHP) throughout the speed range and that 75 percent of the BHP was delivered to the drive wheels throughout the acceleration. Because of these assumptions, the values in Table 2 are probably higher than would occur at an actual site. However, they are reasonable for designing barriers because they include a factor of safety for the design.

Each vehicle was examined for the empty and fully-loaded weight and for engine types specified for that vehicle. As shown in Table 2, a kinetic

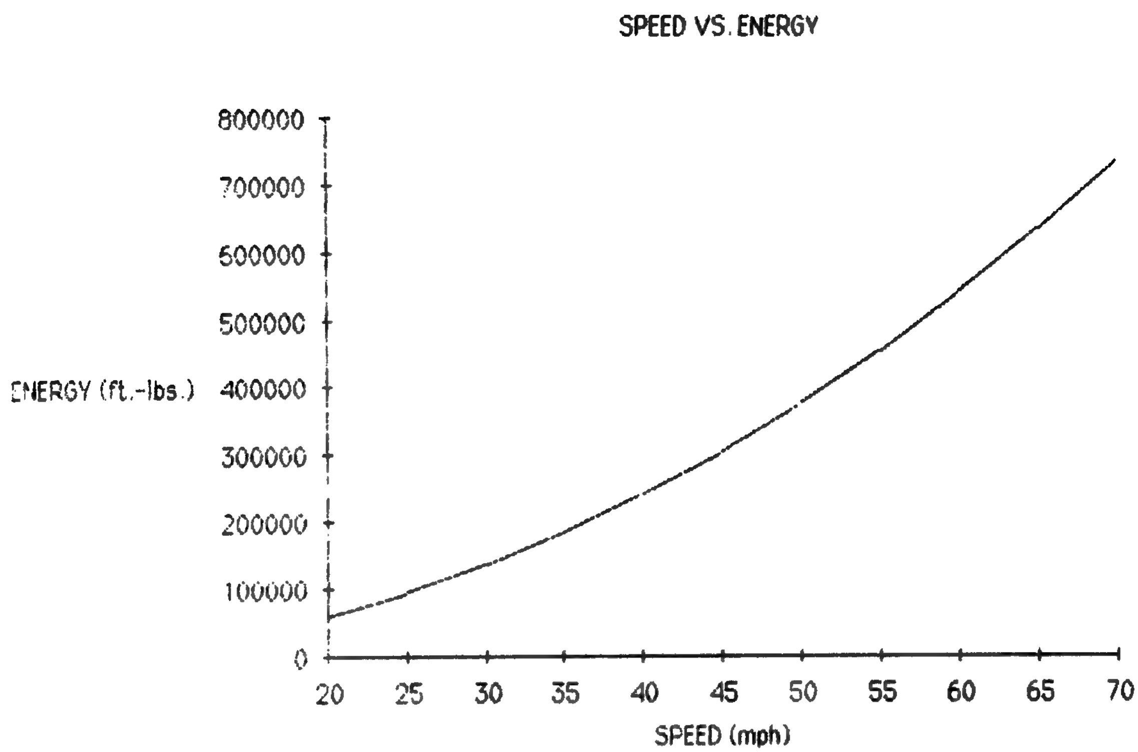


FIGURE 1. The Effect of Speed on Energy for a Standard Weight Vehicle.

TABLE 2. Velocity and Kinetic Energy for Seven Vehicles.[1]

| | | | | | Vehicle Acceleration Distance | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 500' | | 1000' | | 1500' | |
| | Engine | Vehicle Mass (lb) | | | KE | V | KE | V | KE | V |
| Vehicle Type | (NHP) | Curb | Cargo | Test | ft-lb | mph | ft-lb | mph | ft-lb | mph |
| Station Wagon | 130 | 3920 | 0 | 3920 | 398,000 | 55 | 594,000 | 67 | 641,000 | >70 |
| | | | 1080 | 5000 | 435,000 | 51 | 658,000 | 63 | 817,000 | 70 |
| D-150 Std Truck | 90 | 4600 | 0 | 4600 | 318,000 | 45 | 460,000 | 54 | 555,000 | 59 |
| | | | 2900 | 7500 | 372,000 | 38 | 555,000 | 47 | 682,000 | 52 |
| | 140 | 4600 | 0 | 4600 | 435,000 | 52 | 622,000 | 63 | 766,000 | 70 |
| | | | 2900 | 7500 | 514,000 | 45 | 768,000 | 55 | 949,000 | 61 |
| F-250 4x4 Truck | 115 | 8000 | 0 | 8000 | 454,000 | 41 | 678,000 | 50 | 835,000 | 56 |
| | | | 2000 | 10,000 | 486,000 | 38 | 891,000 | 47 | 912,000 | 52 |
| E-350 Super Van | 125 | 4610 | 0 | 4610 | 389,000 | 50 | 549,000 | 60 | 647,000 | 65 |
| | | | 5390 | 10,000 | 512,000 | 39 | 764,000 | 48 | 944,000 | 53 |
| | 225 | 4610 | 0 | 4610 | 576,000 | 61 | >755,000 | >70 | >755,000 | >70 |
| | | | 5390 | | 781,000 | 48 | 1,177,000 | 59 | 1,458,000 | 66 |
| 2 1/2 Ton Truck | 146 | 12,450 | 0 | 12,450 | 589,000 | 38 | 860,000 | 45 | 1,041,000 | 50 |
| | | | 11,400 | 23,850 | 727,000 | 30 | 1,084,000 | 37 | 1,347,000 | 41 |
| | 155 | 9000 | 0 | 9000 | 545,000 | 42 | 773,000 | 51 | 915,000 | 55 |
| | | | 6000 | 15,000 | 657,000 | 36 | 969,000 | 44 | 1,177,000 | 48 |
| | 360 | 9000 | 0 | 9000 | 985,000 | 57 | 1,410,000 | 68 | >1,090,000 | >70 |
| | | | 6000 | 15,000 | 1,210,000 | 49 | 1,800,000 | 60 | 2,145,000 | 66 |
| 60 Pass. School Bus | 158 | 13,000 | 0 | 13,000 | 629,000 | 38 | 915,000 | 46 | 1,104,000 | 50 |
| | | | 7000 | 20,000 | 727,000 | 33 | 1,086,000 | 40 | 1,338,000 | 45 |
| | 235 | 13,000 | 0 | 13,000 | 842,000 | 44 | 1,005,000 | 53 | 1,477,000 | 58 |
| | | | 7000 | 20,000 | 977,000 | 38 | 1,458,000 | 47 | 1,798,000 | 52 |
| 40 Pass. School Bus | 158 | 9000 | 0 | 9000 | 547,000 | 43 | 772,000 | 51 | 910,000 | 55 |
| | | | 6000 | 15,000 | 662,000 | 36 | 973,000 | 44 | 1,177,000 | 48 |
| | 235 | 9000 | 0 | 9000 | 729,000 | 49 | 1,026,000 | 58 | 1,204,000 | 63 |
| | | | 6000 | 15,000 | 886,000 | 42 | 1,304,000 | 51 | 1,584,000 | 56 |

[1] Hancock, K. L. and Michie, J. D. (Southwest Research Institute), "Development of a Vehicular Barrier Testing Program," Final Report, Physical Security Division, U.S. Department of State, Arlington, VA 22209 (April 1985).

energy of nearly 2 million ft-lbs can be achieved if the vehicle is massive enough and has ample distance to reach the required speed. As a comparison, the 4000-lb vehicle traveling at 55 mph in the example above has a kinetic energy of 400 thousand ft-lbs. This energy must be absorbed to stop these potential vehicles and thus prevent a car-bomb attack from being successful.

## IV. Energy Absorption Phenomena

There are several methods for absorbing kinetic energy of a moving vehicle. Figure 2 gives a schematic diagram of this energy transfer and absorption. Some or all of the indicated points may be factors in any given scenario. Ideally, the front of the vehicle absorbs the initial energy. The barrier then absorbs the remainder and transfers it through its foundation into the ground. The disabled vehicle has come to a stop outside the barrier and no kinetic energy remains because the energy has been transferred into deformation of the vehicle and the barrier.

Vehicle-barrier interaction is dependent on the stiffness[1] of the vehicle body, the stiffness and structural strength of the barrier, the type of foundation of the barrier, the location of the center of gravity[2] (CG) of the vehicle and the height of the barrier. The relative stiffness between the vehicle and barrier determines the amount of energy that is absorbed by each one. If the barrier is very stiff, the vehicle must absorb most of the energy. If it is very flexible, the barrier will absorb most of the energy and the vehicle will be damaged less. If the foundation is shallow or not strong enough to support the barrier when it is hit, the barrier will behave like a flexible barrier even though it is constructed of very stiff materials. This occurs because the entire barrier moves when it is being impacted.

Another consideration is the height of the center of gravity with respect to the height of the barrier. Figure 3a shows a typical car with a center of gravity lower than the barrier, and Figure 3b shows a truck with the center of gravity above the barrier. As can be seen, if the CG is higher, the energy in the vehicle may redirect the vehicle over the barrier and most of the energy will remain in the form of forward motion of the vehicle.

For a typical impact, the energy transfer and dissipation go through several stages. At initiation, the bumper contacts the barrier and, if it has not been modified, it will begin to crush and deform immediately, followed by

---

1 The stiffness defines how much a fixed structure will deform when a force is applied to it. So if a piece of thin sheet metal was struck with a hammer, it would have a greater deformation in it than a piece of one-inch thick steel plate. Therefore, the steel plate is stiffer than the sheet metal.

2 The center of gravity is the point in a body which if the body could be suspended from that point it would remain balanced. For design purposes, it is the height where the force acts against the barrier from the kinetic energy of the vehicle.

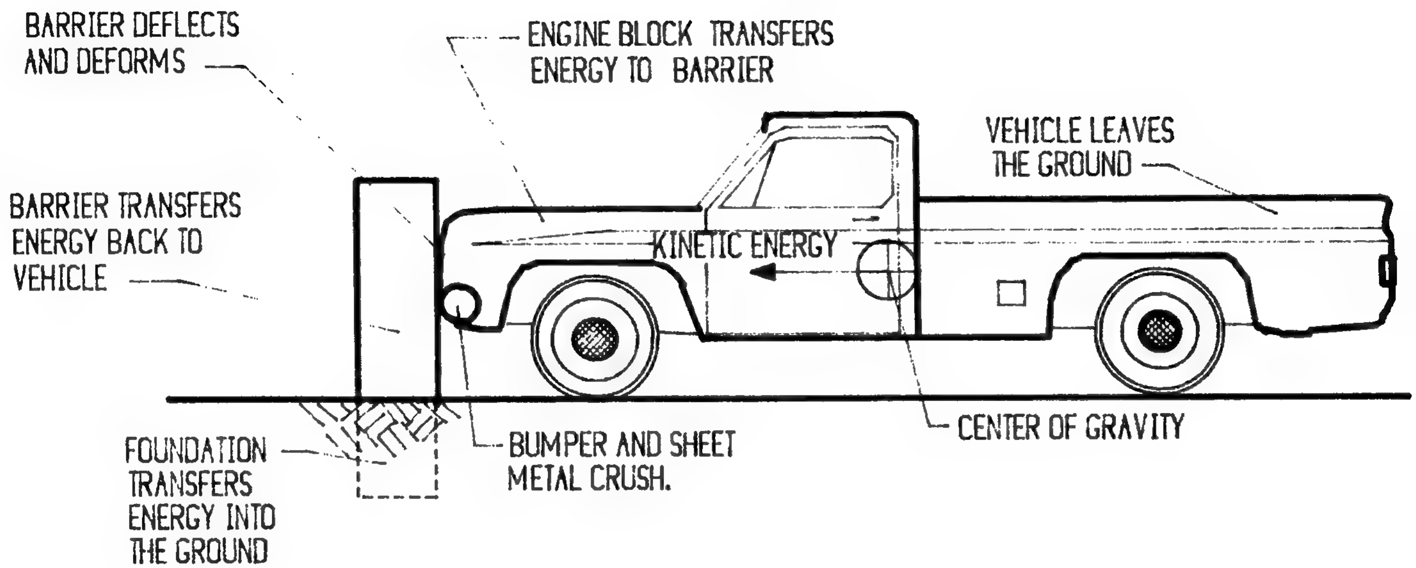


FIGURE 2. Schematic of Vehicle/Barrier Interaction.


FIGURE 3a. Vehicle with Center of Gravity Lower than the Barrier Height.


FIGURE 3b. Vehicle with Center of Gravity Higher than the Barrier Height.

the body metal of the front of the vehicle. The vehicle is absorbing most of the energy at this point. When the engine block comes into contact with the barrier, a second stage of crushing begins. Because the engine block is much stiffer and does not deform as easily as the front of the vehicle, less crushing of the vehicle occurs and energy is transferred to the barrier. The transfer of energy is then dependent on the stiffness of the barrier. If the barrier is very rigid and it has an adequate foundation, most of the energy will continue to be absorbed by vehicle crush. The rear of the vehicle elevates into the air using up the remaining energy. Additional deformation is possible along the body of the vehicle as well. Figure 4 shows an example of a full-scale crash test where this occurred. The cab of the truck literally folded around the bed and the attached weight. During the impact, the rear of the truck lifted into the air until the bed was nearly vertical.

FIGURE 4. Vehicle Deformation.

If the impact occurs with a more flexible barrier, the barrier will absorb energy by deflecting much greater distances and by breaking or deflecting supporting posts. The vehicle does not absorb as much of the remaining energy and will be less damaged. If the barrier is very flexible, it is possible the vehicle could break through the barrier and continue moving forward with the remaining energy.

Some barriers have shallow foundations which will not transfer sufficient energy into the soil. Figure 5 shows the results of such a barrier after a test.

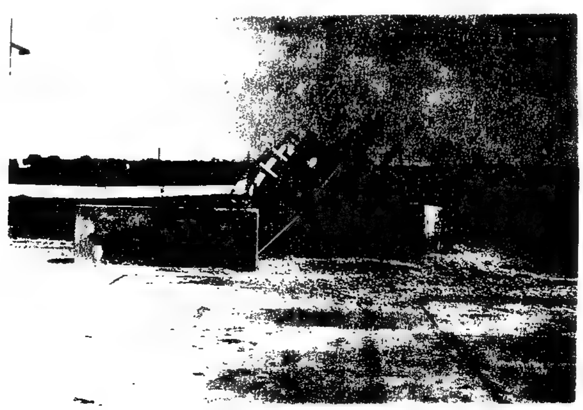

FIGURE 5. Vehicle and Barrier Deformation for a Shallow Foundation Barrier.

The vehicle hit the center of the two "planters." When the engine block contacted the concrete block on the right, both the vehicle and the block became airborne. The concrete block rotated 180° and moved several feet. Another example is given in Figure 6. The concrete wall rotated in the ground using the weight of the soil to help absorb some of the energy. However, because the wall rotated, the center of gravity of the vehicle was higher above the top of the barrier and the vehicle vaulted over the barrier. The remainder of the energy was converted by friction and absorbed in the ground beyond the barrier.

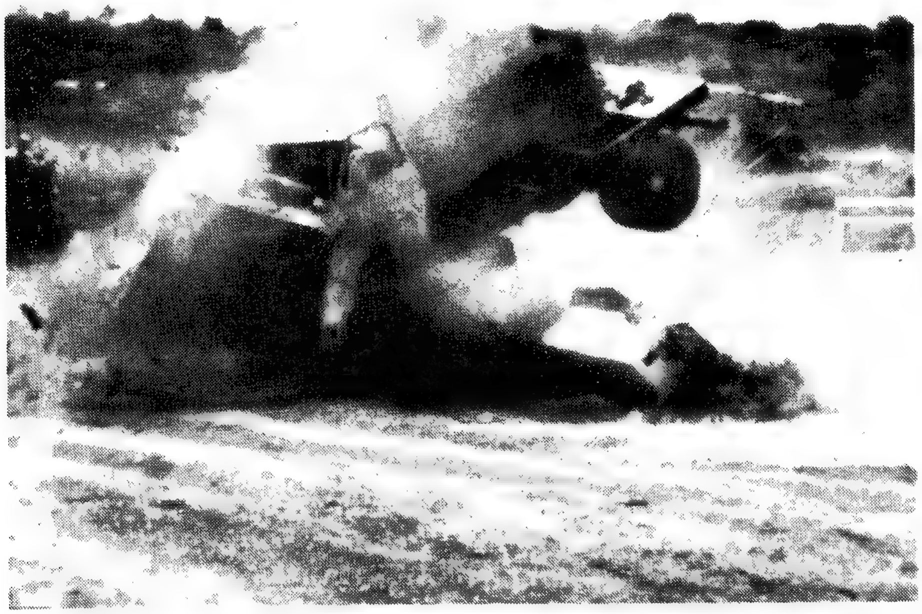

FIGURE 6. Vehicle Vaulting and Barrier Rotation.

A head-on impact is the most likely scenario because the possibility of penetrating a barrier is highest and the kinetic energy is the greatest under such impact conditions. This means that simply redirecting the vehicle is not an effective method of absorbing energy and that the vehicle should be completely stopped at the barrier to protect the installation. Therefore, the barrier and the vehicle itself must absorb the energy.

## V. <u>Barrier Design Principles</u>

There is often only one obstacle that keeps a car-bomb attacker from reaching his goal. That is a physical barrier. Sometimes, the very presence of a barrier, any barrier, is enough to dissuade potential attackers. However, for aggressive attacks barriers designed to withstand large vehicles with their associated kinetic energy are required to protect an installation.

The first consideration is to minimize the kinetic energy associated with the vehicle. Although the vehicle size and power are unknown factors prior to an attack, the speed may be controlled in several ways. If possible, avoiding

or eliminating long straight approaches to entrances and vulnerable facilities is a very effective way of slowing down vehicles. The driver must either slow down to negotiate the curves or he will be forced to drive over curbs and rough terrain which will just as effectively reduce speed. Adding speed bumps to straight approaches will have a similar effect. Shrubbery and rolling landscaping can also inhibit vehicles crossing green belts around installations.

These measures are suggestions to reduce speed and thereby reduce the kinetic energy of a vehicle before it reaches a barrier. The lower the kinetic energy of the vehicle at impact, the less barrier strength is required and the less expensive its installation is likely to be.

The design of the barrier requires consideration of the distance beyond the barrier that is available before the explosive-laden vehicle can affect the installation. If there is enough space available, the barrier can be relatively flexible; its prime function being to disable the vehicle and bring it to rest. The barrier must be very stiff if that space is not available. Its function is now to completely stop the vehicle before it penetrates the barrier.

The height of the barrier is very important. If the center of gravity of the vehicle is higher than the barrier, the vehicle may vault over the barrier and continue forward. However, the higher the barrier, the stronger the base has to be to resist the load applied by the impact. If it is impractical to design a barrier of the required height, a method for "capturing" the bumper may be devised. Figure 7 shows a channel on a bollard system that effectively prevented a penetration/vault by snagging the bumper in the exposed channel. There were indications during the test that the truck might have gone over the bollards if the channel had not been in place.

Finally, the structural adequacy of the barrier must be considered. Figure 8 is a picture of a concrete wall that was too thin to absorb the kinetic energy of a 2-1/2 ton truck traveling at 50 mph. The truck blasted through the wall, breaking one piece of the steel rebar and shattering concrete in the impact area. If the truck had not flipped end over end, it may have continued for a considerable distance.

Although detailed design of barriers to stop car-bomb vehicles is beyond the scope of this paper, these basic considerations have been presented to provide guidelines for protecting installations.

## VI. Conclusions

All moving objects contain kinetic energy which must be absorbed in some manner if the object is to be stopped. When the moving object is a car-bomb attack vehicle, this energy must be absorbed by deforming the vehicle and/or the physical barrier during an impact. The absorption of the kinetic energy is dependent on the relative stiffnesses of the vehicle and the barrier. When the barrier is stiffer, the vehicle absorbs more energy and the damage to the vehicle is greater. The height of the barrier will also affect its ability to stop a vehicle. If the center of gravity of the vehicle is higher than the

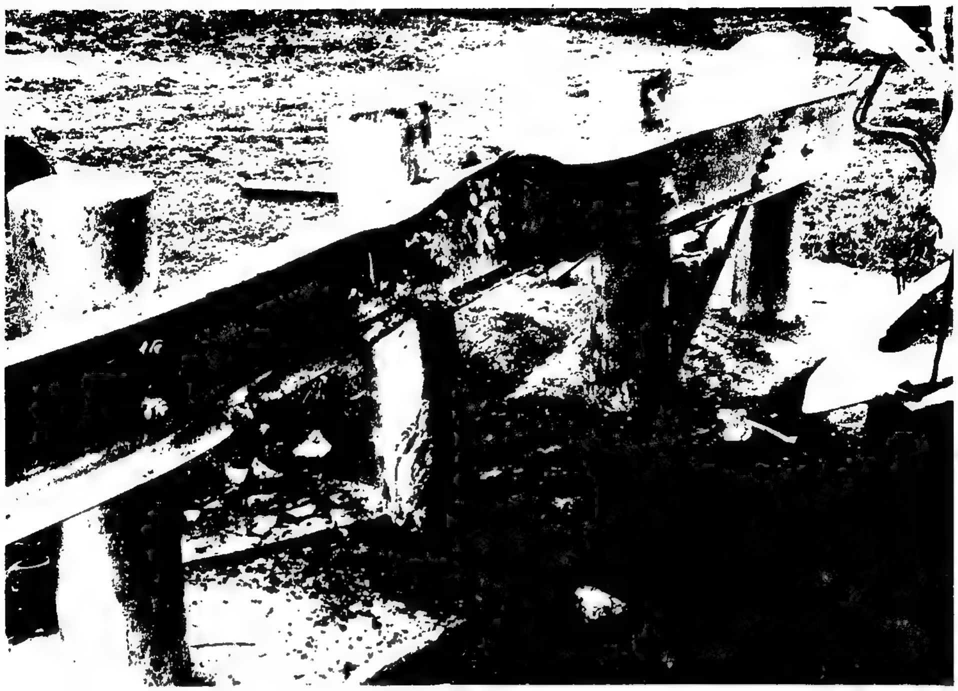


FIGURE 7. The Channel "Captured" the Bumper to Keep the Truck from Vaulting.


FIGURE 8. The Barrier was Structurally Weak, Allowing the Vehicle to Penetrate.

barrier, the vehicle may launch over the barrier and continue moving toward the installation.

The energy to be absorbed is dependent on the speed and mass of the vehicle. Although the mass of the vehicle cannot be controlled, methods have been described to reduce the speed of the vehicle as it approaches a barrier. Basic criteria for designing barriers to protect new and existing installations have also been formulated.

Installations can be effectively protected against car-bomb attackers if the phenomena of energy absorption to stop a vehicle is understood. The concepts are straightforward; however, the actual interaction between a vehicle and barrier at impact are very complex. Full-scale crash testing is the only definitive method for evaluating the performance of a barrier. Reference 1 provides a test procedure and test specification used for some government facilities. This provides additional barrier guidelines that are currently in use.

## REFERENCE

1. Hancock, K. L. and Michie, J. D. (Southwest Research Institute), "Development of a Vehicular Barrier Testing Program," Final Report, Physical Security Division, U.S. Department of State, Arlington, VA 22209 (April 1985).

<u>DESIGN NOTES</u>

BY
MICHAEL W. DAVIS

## ACTIVE BARRIER PERFORMANCE SPECIFICATION

1.0 EFFECTIVENESS IN ARRESTING ATTACK VEHICLES
- 1.1 MASS
- 1.2 IMPACT SPEED
- 1.3 CORRESPONDING KE
- 1.4 VEHICLE GEOMETRY

2.0 ECONOMICS
- 2.1 EQUIPMENT COST
- 2.2 INSTALLATION COST
- 2.3 SHIPPING WEIGHT
- 2.4 SHIPPING SIZE
- 2.5 INSTALLED COST

3.0 AESTHETICS (INSTALLED)
- 3.1 WHILE IN A PROTECTIVE MODE
- 3.2 WHILE IN AN UNPROTECTED MODE
- 3.3 COLOR
  - DAYTIME
  - NIGHTTIME
- 3.4 DIRECTION
  - FROM INSIDE
  - FROM OUTSIDE
- 3.5 NOISE OF OPERATION (ROUTINE OPERATION Db)
- 3.6 SEPARATE HYDRAULIC HOUSINGS, ETC.

4.0 OPERATIONAL CYCLE TIME
- 4.1 DESCRIPTION OF OPERATIONAL CYCLE
- 4.2 PROTECTIVE TO OPEN TIME
- 4.3 OPEN TO PROTECTIVE TIME

5.0 MAINTENANCE REQUIREMENTS
- 5.1 FREQUENCY OF PREVENTATIVE MAINTENANCE
- 5.2 ACCESSIBILITY TO MECHANICAL COMPONENTS
- 5.3 AVAILABILITY OF MECHANICAL COMPONENTS
  - SPECIAL COMPONENTS
  - OVER THE COUNTER COMPONENTS
- 5.4 CORROSION PROTECTION

6.0 CLIMATE AND ENVIRONMENTAL EFFECTS
- 6.1 IMMUNITY TO SAND
- 6.2 IMMUNITY TO SNOW AND ICE
- 6.3 IMMUNITY TO RAIN
- 6.4 IMMUNITY TO HEAT

Do's and Don'ts of Vehicle Barriers. (by Michael Smith)

Do's

1. Locate support equipment (i.e., hydraulic power, generator, batteries, etc.) away from the guard posts to lower the threat of sabotage.

2. Provide a thorough training program for operators.

3. Insist on an operation and maintenance schedule from the manufacturer.

4. Have an alternate route plan in the event of a failure of the barrier to allow traffic to flow, or emergency evacuation.

5. Provide adequate environmental protection of support equipment against freezing or overheating.

6. Insure the barrier is compatible with other security elements. For example, don't install a barrier with a perimeter chain-link fence (Ref 1).

7. Avoid a barrier that creates a "fortress" appearance. Consider the aesthetics of the barrier.

8. Consider the installation costs as part of a total package for a barrier. Installation of some commercial barriers are the same or greater than the barrier.

9. Consider the application of the barrier. Is a hard or soft stop needed? All of the barriers-high are lethal (page 7).

10. Insure that contract guards, union, and security officers are in agreement as to the deployment, operation, and responsibilities of a barrier.

11. Locate vehicle barriers as far from the building/asset as needed to provide explosive safety according to References 4 and 5.

12. Use passive/active barriers (those which must be activated, retracted or withdrawn to allow a vehicle to pass) whenever possible. This type removes the unreliability problem associated with a guard having to activate a barrier under stressful conditions.

13. Consider use frequency carefully in selecting vehicle barriers. Some activities are using command vehicles, trucks, or construction equipment during off-duty hours to back-up gates or fences.

Don'ts

1. Install sunken (underground) barriers unless the excavation can be drained. Collecting water will cause corrosion and freezing weather may incapacitate the mechanism.

2. Use push button switches.

3. Provide vehicle barriers at gate ways without providing equivalent perimeter barriers except in rare situtations.

4. Protect the perimeter of an entire installation lightly, its probably more cost effective to protect specific buildings or zones.

5. Provide perimeter vehicle barriers that are not patrolled or frequently observed. Most types can be overcome quickly with simple tools or ramps if no one can see that they are being overcomed.

6. Place guard posts next to the vehicle barriers.

7. If separate barriers are used for exits and entrances, do not deploy or cycle only the entrance. Require access also for exit.

8. Have a long straight-away (greater than 175 feet) to a barrier.

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2. U.S. Army. Use of barrier to deny high speed approach, for countering terrorist situations, U.S. Army Military Police School Field Circular 19-112, Aug 1984.

3. State Department. Performance criteria for vehicular arrest system, 1984.

4.Naval Facilities Engineering Command. Structure to resist the effects of accidental explosion, NAVFAC P-397, Washington, D.C.

5. Naval Sea Systems Command. NAVSEA OP 5/1: Ammunition and explosives ashore, safety regulations for handling, storing, production, renovation, and shipping. Washington, D.C., May 1969.

6. Naval Civil Engineering Laboratory. Personal communication with Sandia Laboratories.

7. ___________. Contract Report: Characteristics of design threats to be used in the security assessment and design of Naval shore facilities. Long Beach, Calif., Management Guidance Institute, Inc., May 1983 (Contract N62474-82-C-8280).

8. Naval Sea Systems Command. Vehicle barrier information, Aug 1984.

- SNL dual pipes/single cable (10,000 lb at 14 mph, type - steel cable barrier)
- Single buried concrete filled pipe (unknown)
- Delta Scientific TT-207 (10,000 lb at 31 mph, type - ramp)
- Delta Scientific TT-241 (10,000 lb at 20 mph, type - ramp)
- Frontier MAC-H (10,000 lb at 38 mph, type - ramp)
- Robot SCB crash beam (unknown)
- Entwistle dragnet (10,000 lb at 40 mph, type-arrestor)
- SNL crash beam (10,000 lb at 67 mph, type - swing beam)

Figure 1. Sandia barrier tests (unpublished data).

| Movable | Fixed |
|---|---|
| Chain link gate/wire rope | Chain link fence/wire rope |
| Semaphore | Concrete shapes |
| Sliding beam | Buried tires |
| Vehicle | Steel guard rails |
| Impalements | Walls |
| Rotating/retracting devices | Rock-filled V-fence |
| Arrestors | Sand-filled oil drums/tires |
| Pit/ramp | Trees |
| Tire shredder | Trences/berms |
| | Hedgehogs |
| | Pole fields |

Figure 2. Vehicle barrier types.

- Aesthetics
- Barrier Location
- Compatibility with Other Security Elements
- Cost
- Operation
  - continuous
  - emergency
- Threat
- Environmental Effect
- Design
  - mechanics
  - hard vs. soft stop
- Installation Requirements

Figure 3. Considerations.

# THE APPLICATION OF AIRCRAFT ARRESTING SYSTEM TECHNOLOGY TO VEHICLE BARRICADES

By: Kevin Mulligan
Project Manager
All American Engineering Company

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M-1616

# THE APPLICATION OF AIRCRAFT ARRESTING SYSTEM TECHNOLOGY TO VEHICLE BARRICADES

by: Kevin Mulligan
All American Engineering Company

This paper details the application of existing aircraft arresting system technology to solve a new problem of stopping unwanted vehicles from entering secure areas.

**OLD PROBLEM:**

How to safely prevent jet aircraft from departing the runway end during landing overrun or aborted take-off incidents.

**SOLUTION:**

Aircraft Arresting Systems that utilize energy absorbers attached to cross runway nets or steel cables to engage the aircraft and gently bring it to a safe stop within a short distance.

Figure 1. Typical Aircraft Arresting System

**NEW PROBLEM:**

How to prevent unwanted vehicles from entering secure areas where friendly traffic is allowed.

**SAME SOLUTION:**

Vehicle security barricades (scale size versions of aircraft arresting systems) that are quickly activated to engage an intruding vehicle and stop it within a short distance by absorbing its kinetic energy.

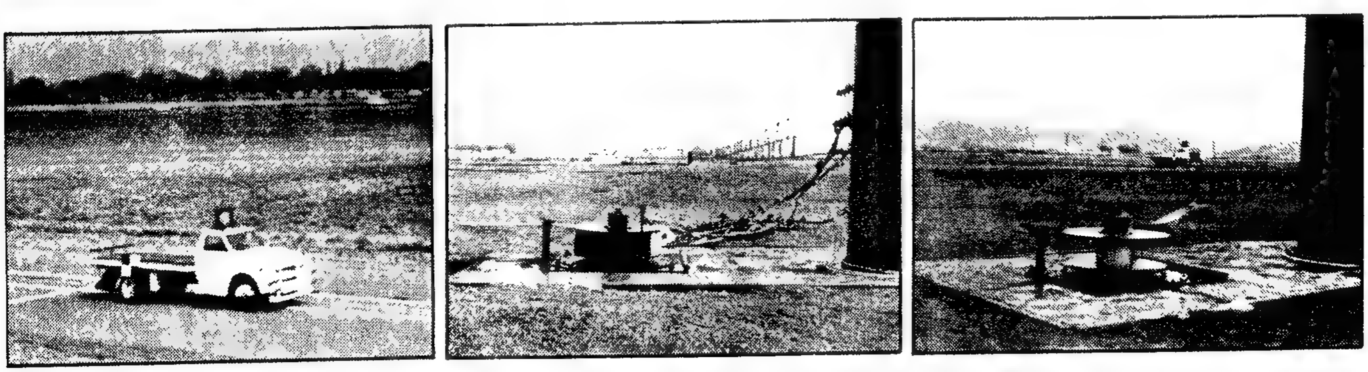


Figure 2. Vehicle Security Barricade

## AIRCRAFT ARRESTING SYSTEM TECHNOLOGY

The United States Navy first realized the usefulness of land-based aircraft arresting systems over thirty years ago. In the early 1960's, the U.S. Navy, U.S. Air Force and U.S. Marine Corps fully integrated safety arresting devices into their land-based operations. Today, every U.S. Military runway is protected by multiple arresting gears (over 1,000 installed).

All American Engineering Company (AAE) invented the Water Twister® energy absorber in the late 1950's. This technology was subsequently applied to the development of aircraft arresting systems including the standard U.S.Navy E-28 and U.S. Air Force BAK-13 models. AAE is today, the worldwide leader in arresting equipment technology with nearly 2,000 systems in service in more than 50 countries.

State of the art arresting gears utilize two energy absorbers (one on each side of the runway) attached to an engaging device across the runway. For aircraft equipped with tailhooks (as with most U.S Military fighters), a steel cable lying on the runway is used to engage the tailhook (just like on aircraft carriers). For aircraft without tailhooks, a cross runway net is suspended above the runway to envelope the aircraft (Figure 3.).

Once an aircraft engages the cable or net of a Water Twister® arresting gear, it unwinds a nylon tape assembly (band) from the energy absorber tape drum causing a vaned rotor to turn inside a fluid filled housing. The fluid turbulence caused by this rotation produces a torque proportional to the rotor RPM squared. This simple water turbine converts the aircraft's kinetic energy to heat which is dissipated in the fluid. The retarding force developed by the torque is applied to the aircraft through the tapes and engaging device and decelerates it to a complete stop within 600-1400 feet from the point of engagement. This relatively long runout distance is usually required to keep the retarding force on the aircraft below some maximum allowable value, such as 2 G's.

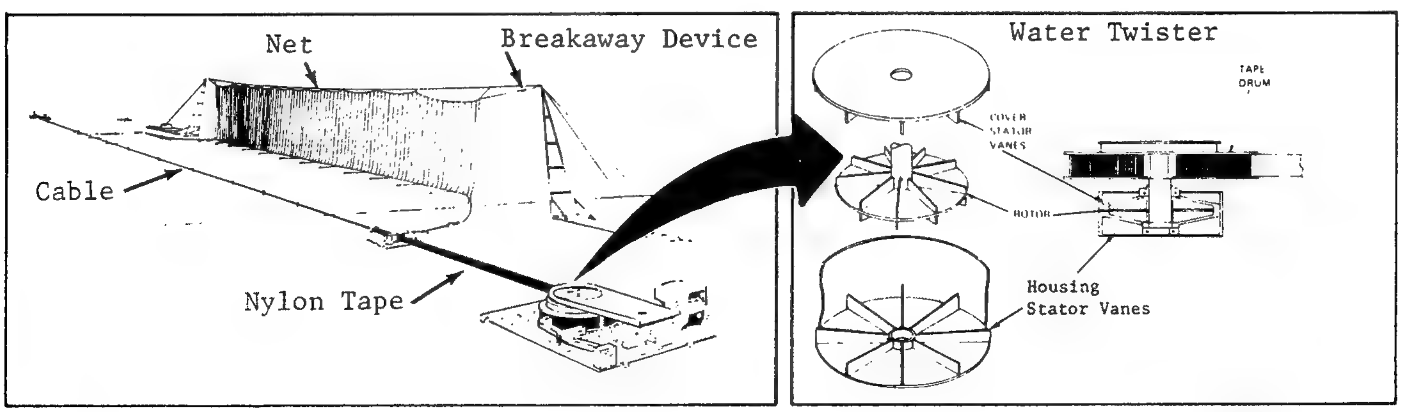



Figure 3. Typical Aircraft Arresting Gear Configuration & Energy Absorber

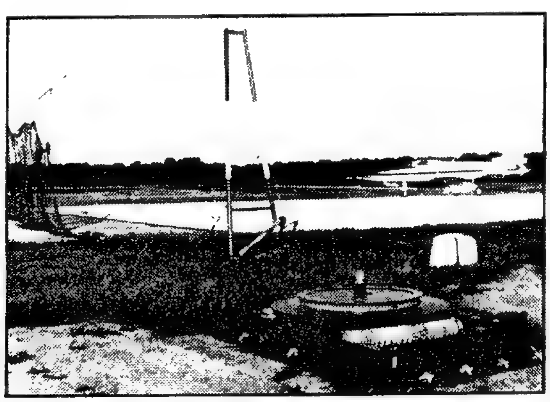
## ENERGY ABSORBERS

Various Water Twister energy absorber models have been developed and tested to satisfy a wide range of energy absorbing requirements. Water Twister sizes are designated by the diameter of their absorber housing. The Model 64 arresting gear (i.e. 64 inch diameter housing) is the largest built to date. It was successfully tested with multiple arrests of a B-52 aircraft at Edwards Air Force Base in 1972 in a program sponsored by the Federal Aviation Administration (Figure 4). The system absorbed 178 million ft.-lbs. of energy by arresting the 305,000 pound aircraft while traveling at 132 miles per hour. Energy absorber design capacity is 400 million ft.-lbs.


Figure 4. Model 64 System Arresting B-52 Aircraft

The most prevalent size of Water Twister in operational service is the Model 44. They are sized to handle tactical fighter aircraft in the 20,000 to 80,000 pound range and have a typical absorption capacity of 50-100 million ft.-lbs. (Figure 5). Model 44's have been tested by the U.S. Navy at engaging velocities up to 250 miles per hour. Similar to Model 44 arresting gears are a smaller line of tactical fighter systems designed specifically for light weight aircraft (up to 40,000 lbs.). These are designated Model 34. There are currently more than 800 Model 34 and 44 arresting systems in operational use in 30+ countries, not including 400 U.S. military designated Water Twisters (BAK-13, E-28, M-21) which are derivatives of the Model 44.

Model 44 Cable System Arresting F-4 Aircraft

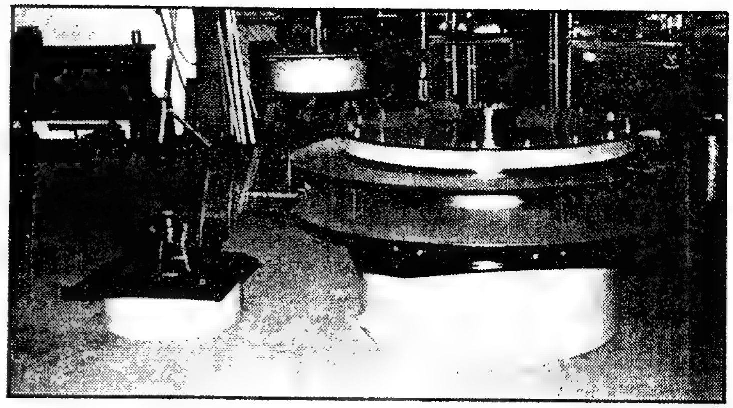


Expeditionary Model 34 Net System (X-29A Aircraft)

Simulated Aircraft Engaging Model 34 Net at AAE Test Facility

Figure 5.

Model 34, 44 and 64 Water Twisters



Model 24 and 44 Water Twister

Figure 6. Size Comparison

Smaller versions of Water Twisters have also been developed and used for different energy absorbing requirements. The Model 24 and Model 18 configurations are installed alongside landing strips and utilized to absorb the forward kinetic energy of cargo as it is extracted from low flying aircraft in AAE's Air Cargo Extraction System (ACES) (Figure 7). ACES provides an alternative to aircraft vulnerability while sitting on a runway and damaged cargo from parachute delivery. Model 14 and Model 12 Water Twisters are used to arrest Remotely Piloted Vehicles (RPV) and as shuttle arresters on AAE's line of RPV launching systems (Figure 8).

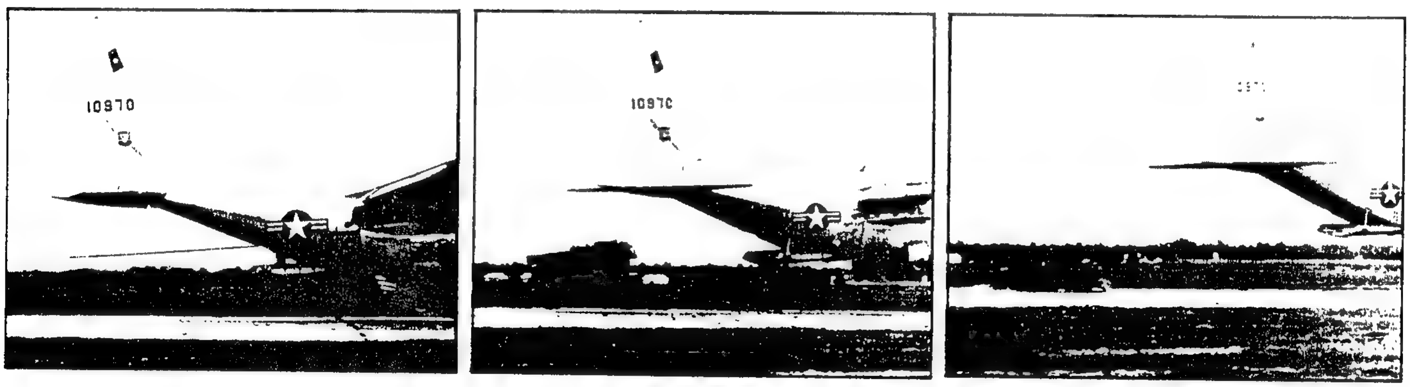


Figure 7. Model 24 Water Twisters Extracting & Arresting Vehicle Size Cargo

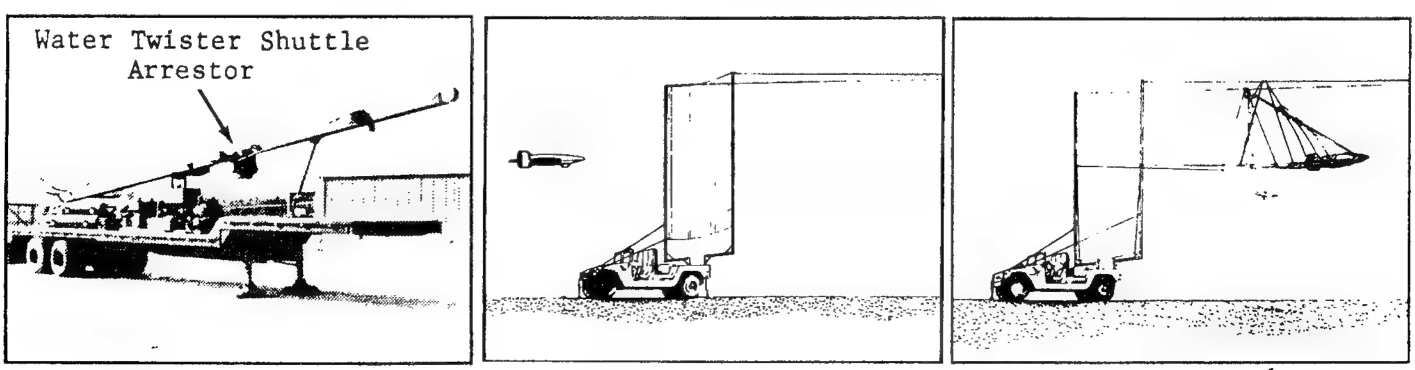



Figure 8. Model 12 and 14 Water Twisters used for Launch and Recovery of RPV's.

## INSTALLATION

Water Twister aircraft arresting gears are designed for permanent concrete installations, for expeditionary steel baseplate installations, and for mobile (1 hour) installations (Figure 9). They can be pre-positioned and hidden under the runway surface or transported and installed quickly where and when needed.

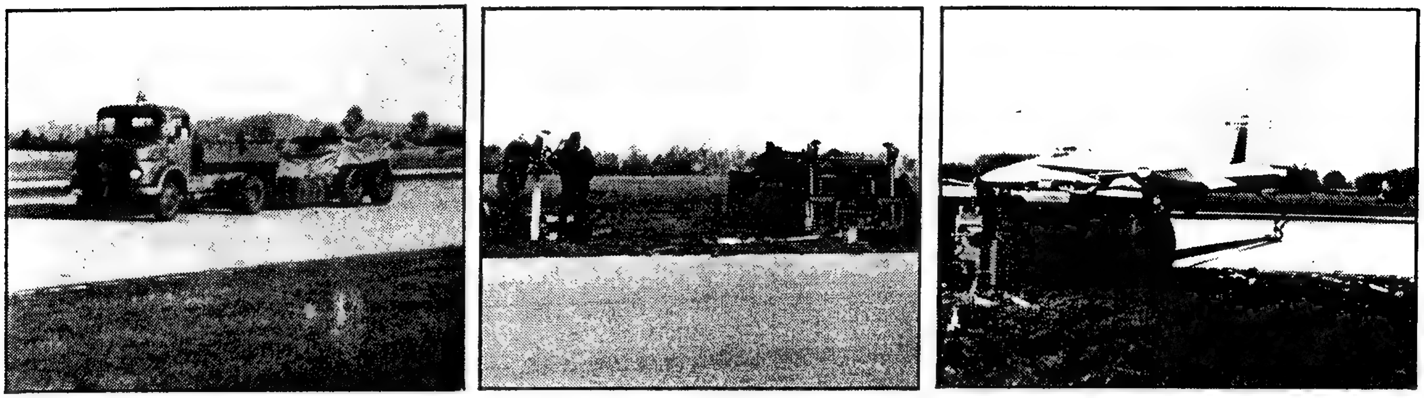
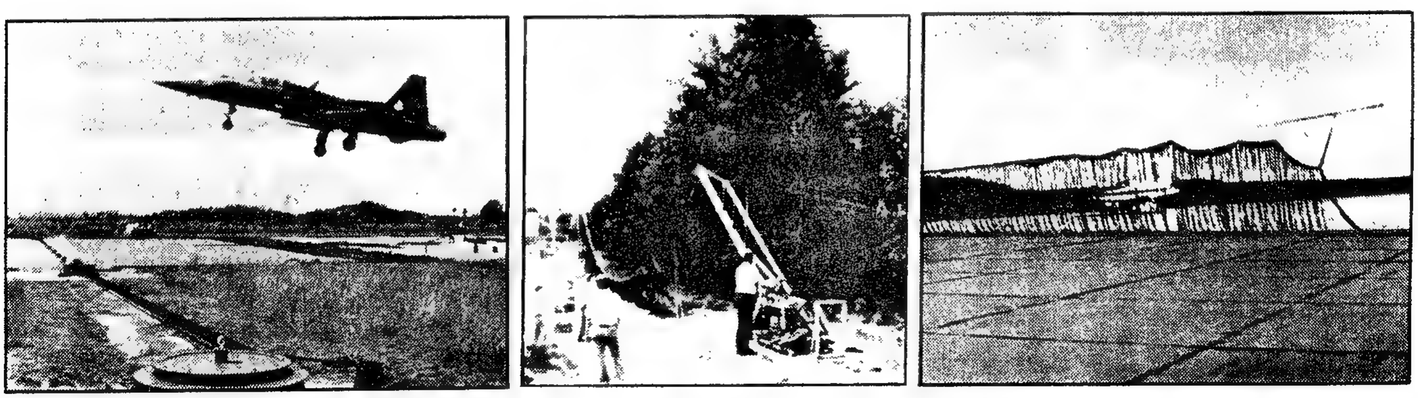


Figure 9. Mobile Arresting Gear (F-18 Aircraft)

## NET & STANCHIONS

Arresting system net assemblies are specifically designed to minimize localized loading on the aircraft and reduce damage during arrestment. The net can lie flat on the runway when not required to permit normal traffic. It can be raised within 3-5 seconds using electrical power or self-contained stored energy both from the runway site or air traffic control tower (by radio remote control is required).



Net flat on runway . . . . . . being raised . . . . . . ready for arrest.

Figure 10.

## VEHICLE SECURITY BARRICADES

Scale sized arresting systems can be utilized to stop terrorist or other unwanted vehicles form entering secure areas. In entrances or other areas where normal traffic is allowed, permanent concrete obstructions cannot be used. In this scenario, pop-up nets (steel mesh or other) that envelop the vehicle and absorb its kinetic energy are ideal. Also, in locations where general civilian traffic is allowed, non-lethal stopping devices are preferred to destructive pop-up barrier methods to prevent injury in the event of inadvertent activation or if the intruders are friendly (peace demonstrators, etc). Vehicle arresting systems clearly provide an alternative to existing destructive barriers by prohibiting admission without lethal force.

Figure 11 shows a Model 18 vehicle arrester as initially tested by AAE in the 1960's for a barricade proposal to the Delaware State Police. This program proved the acceptability of using scale size aircraft arrestors to stop vehicles.

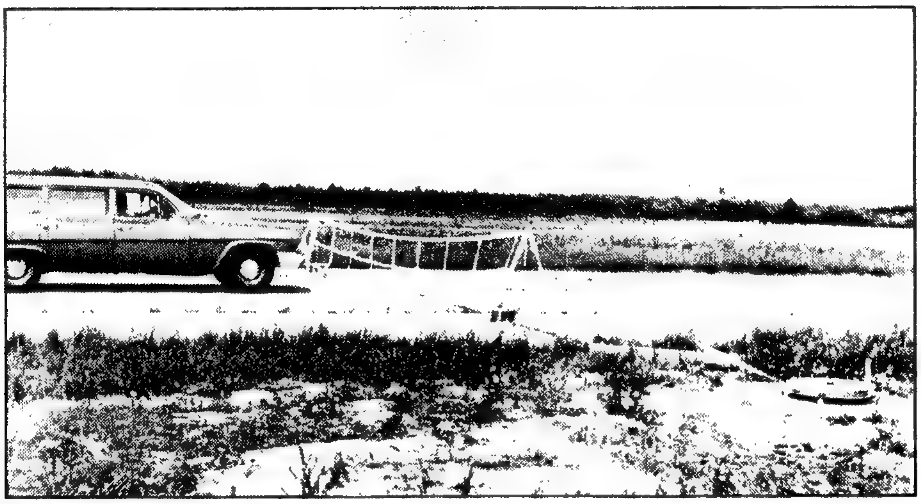


Figure 11. Original Barricade Testing

Figure 12 shows Model 24 Water Twister energy absorbers used with a security barricade developed by the New Mexico Research Institute under contract to Kirtland Air Force Base. The system was successfully tested and will be installed at numerous bases to prevent unwanted vehicles from entering secure areas adjacent to runways. This system was designed to meet specific site geometry constraints and therefore includes specialized tensioning and breakaway techniques.

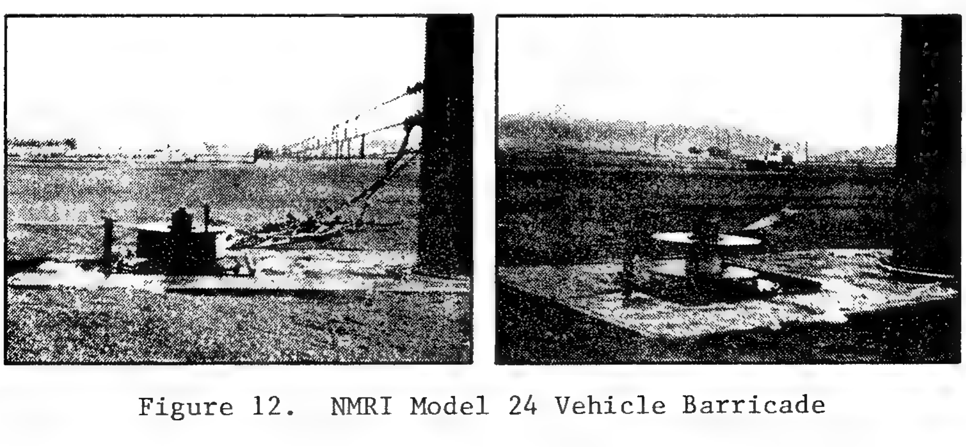


Figure 12. NMRI Model 24 Vehicle Barricade

AAE's concept of a general security barricade system is shown in Figure 13. This permanently installed configuration consists of Model 24 energy absorbers which are capable of arresting vehicles in the 4,000 to 20,000 pound range. It includes concrete foundations, electrically operated stanchions capable of remote operation, and a trough to store the net under the road surface. The net can be activated in 1-3 seconds.

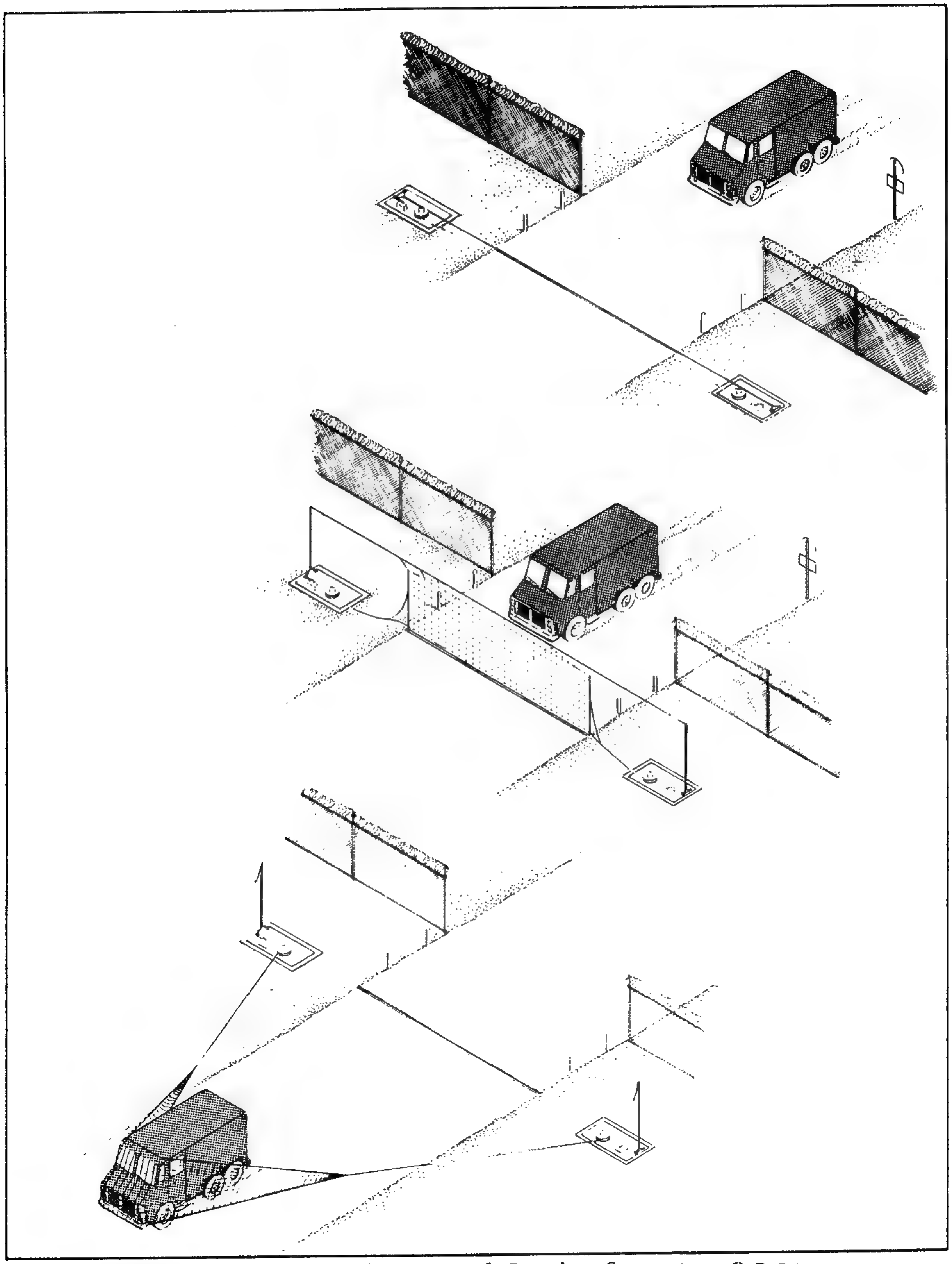
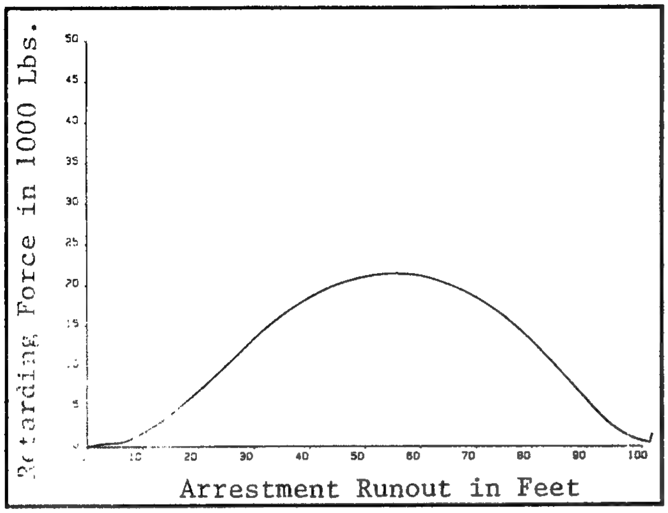


Figure 13. General Barrier Concept 000724

The system will arrest a vehicle weighing 10,000 pounds and traveling at 60 mph within 100 feet while imposing a maximum force on the vehicle of 2.1 G's. Typical computer simulated performance curves for these conditions are shown in Figure 14 which plots the force on the vehicle and vehicle velocity as a function of the runout distance.



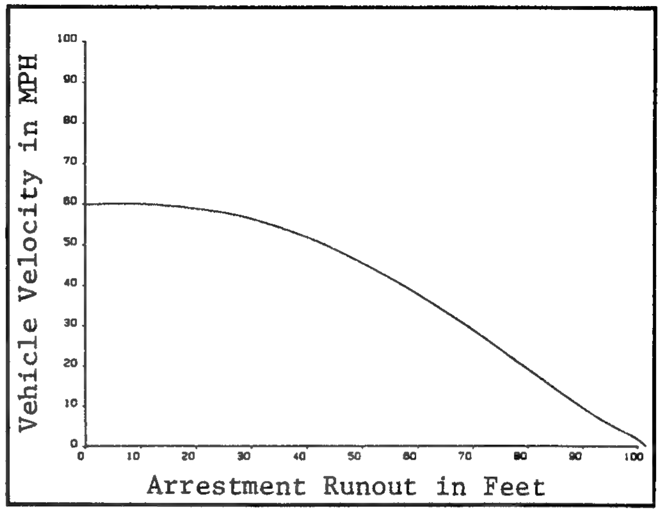




Figure 14. Typical Performance Curves (10,000 lbs. Vehicle at 60 mph)

For the absorption of energy with Water Twisters, all of the referenced parameters are interrelated and can be altered to meet specific requirements. For instance, if the runout distance is decreased, either the weight and velocity can be reduced to maintain the same G force or the maximum applied load can be increased to absorb the same amount of energy. The vehicle's total kinetic energy is simply the area under the force vs. runout distance curve. This curve can be extended in any direction for different requirements.

To further customize system performance and energy absorption capabilities, the energy absorber's rotor size and tape stack geometry can be configured to meet specific requirements of vehicle weight and speed, and installation geometry and runout distance. Reducing the rotor size on a Water Twister decreases the torque developed during each revolution. Conversely, by reducing the tape stack diameter, the rotor RPM is increased for each foot of tape that is unwound. These and other geometries of the system allow a large combination of performance possibilities within a standard size energy absorber. AAE currently has approximately 20 different configurations of the Model 44 system alone to meet specific customer requirements.

Water Twister energy absorbers are also designed to be self compensating for different vehicle weights and engaging velocities. The only input that determines how much torque is developed is how fast the rotor turns. The only input that determines how fast the rotor turns is how fast the vehicle unwinds the nylon tapes. This, in turn, is directly related to the individual vehicle's velocity and weight (relative to the G load developed) throughout the arrestment process. Thus there are no complicated feedback or retarding force application or control mechanisms necessary to stop all vehicles within the same runout distance.

Figure 15 details the performance of the same system while arresting a 4,000 pound vehicle traveling at 35 mph and compares this arrestment to that of the 10,000 pound vehicle arrested at 60 mph (reference Figure 14). As shown, the 4,000 pound vehicle at 35 mph (typical car) experiences a 1.1 G maximum retarding force during the arrestment.

The maximum G load applied to the vehicle can be specified for a range of engagement conditions as desired. High G loads may be desired in certain instances to incapacitate the vehicle driver while low loads may be necessary in others to reduce the possibilities of injury.

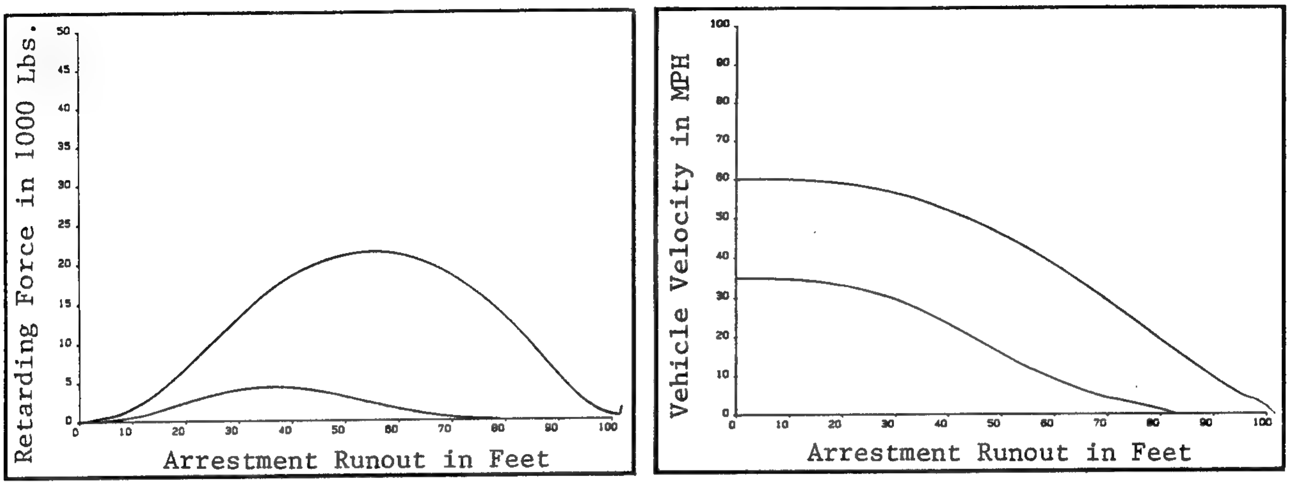



Figure 15. Self-Compensating Features for Different Engagement Conditions

If desired, the energy absorbers and stanchions can be installed underground or can be equipped with protective shelters. Figure 16 depicts a permanent installation with the entire barricade system installed below ground to eliminate obstructions and prevent possible tampering.

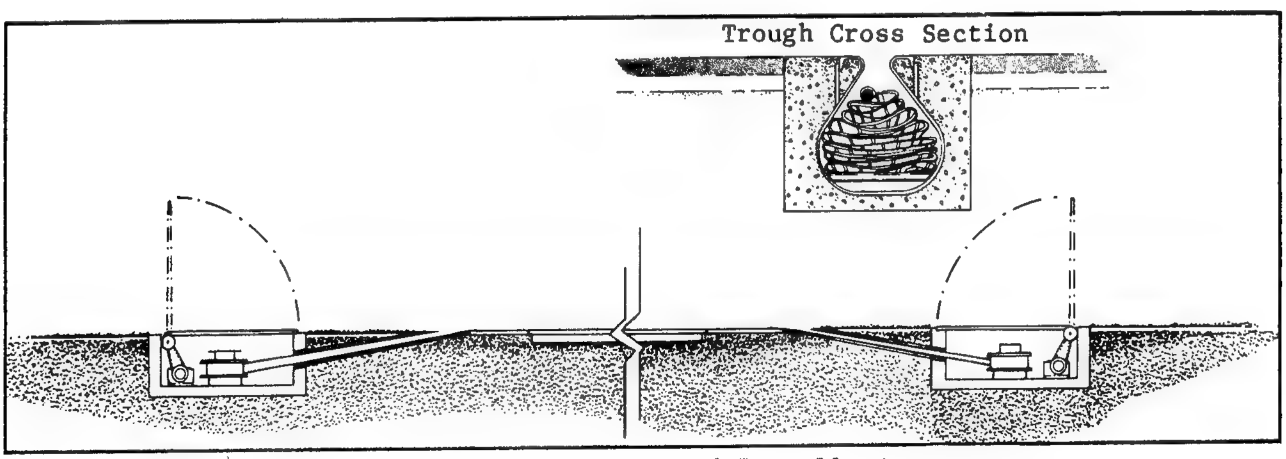



Figure 16. Below Ground Installation

Figure 17 shows an expeditionary barricade installation that can be used when permanent foundations are not desired or when times or location prohibit their use. In this scenario, the components are attached to a common baseframe and installed on an earth surface with a series of anchors (similar to those used on expeditionary aircraft arresting gears). Expeditionary concrete or asphalt anchors can also be used to allow installation on existing hard surfaces. In the temporary mode, as well as in permanent installations, the net can lie flat on the road surface when not in use to permit normal traffic. (See Figure 10 for similar aircraft net configuration.)

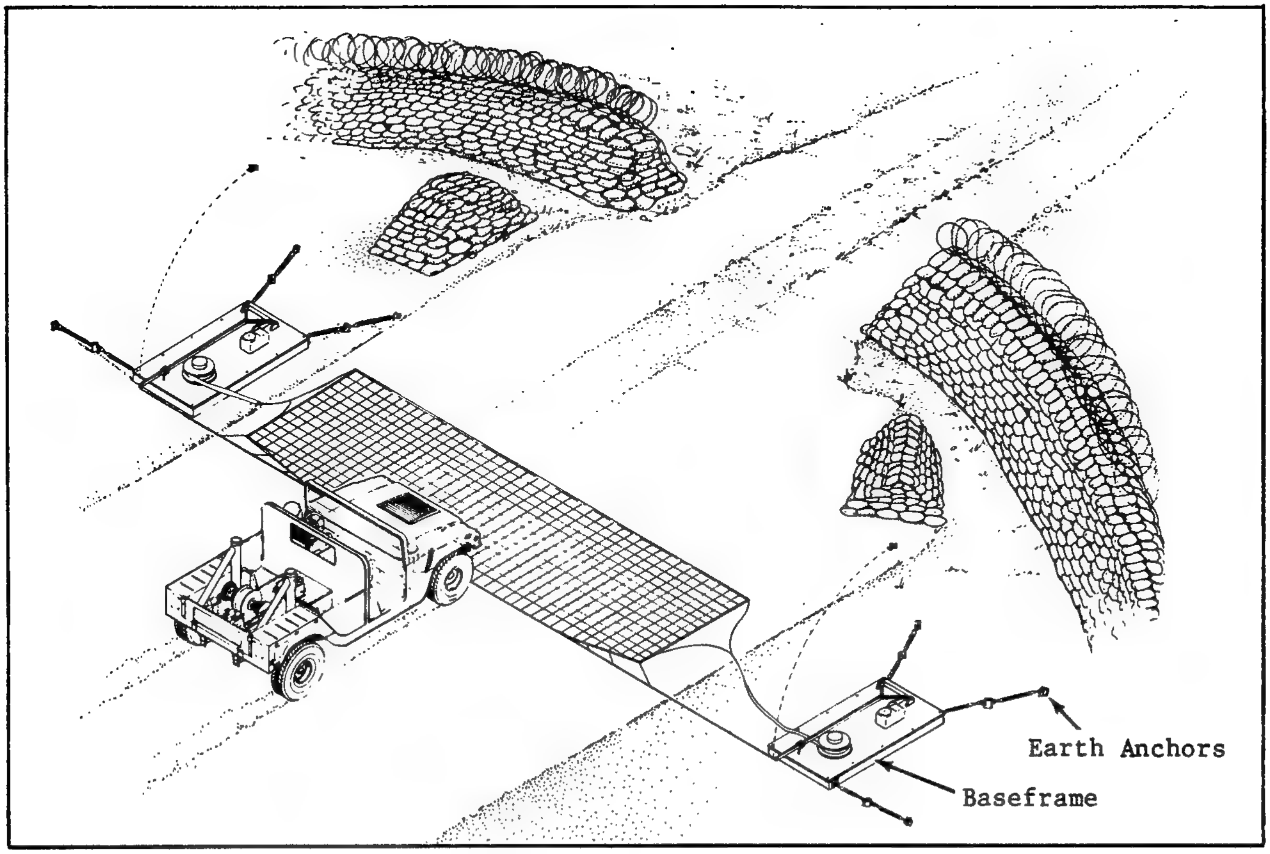



Figure 17. Expeditionary Barricade Installation (Allowing Normal Traffic)

Figure 18 depicts a mobile barricade concept for use with the expeditionary configuration when security barriers are needed in remote areas or required quickly where special handling equipment is not available or desired. Forward operating areas (like the marine barracks in Beirut) or temporary secure areas (when meetings are held in unsecure locations) are ideal scenarios for such a system. In the mobile configuration, the energy absorbers, stanchions and all necessary power supplies and installation tools and hardware are installed on a common baseframe for ease of transportation and installation. Only a tow vehicle and four laborers are required in this scenario to install the system in one hour on any surface. Once installed, it is self-sufficient and can be controlled with hand held radios. The baseframe is moved by means of a transporter which hoists the system into place, transports it behind a tow vehicle and lowers it into place for installation. The transporters are also capable of self-loading and being transported on a single C-130 aircraft.

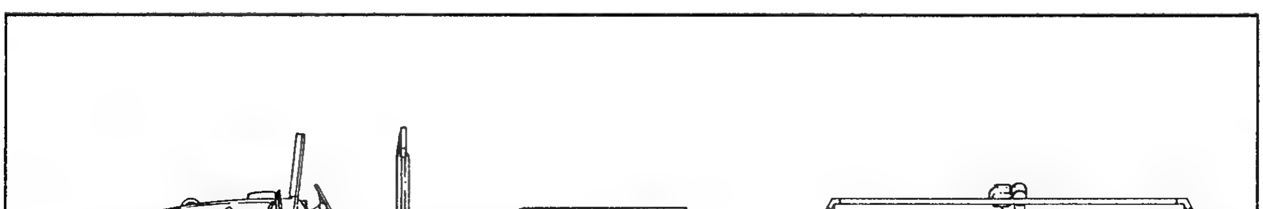


Figure 18. Mobile Barricade Concept with Transporter

## BARRIER ACTIVATION

For all installation configurations, the net assembly can be activated in a number of ways:

* Manually from the barricade site.
* With electrical power from the site or some remote area.
* With stored energy (pneumatic or hydraulic) from the site or some remote area. (Recharging gasoline engines can also be provided if desired).
* Automatically by vehicle velocity sensors.

All remote control operations can either be by direct wire or by radio command.

## BARRIER NET

The barricade engaging net is unlike the aircraft arresting net in that it does not have to be complex to evenly apply a retarding force to an irregular surface. It can also be metallic or some other material to enhance its life and to prevent specially equipped terrorist vehicles from cutting through nylon. The net is specifically designed to hold onto the arrested vehicle even after it stops. Nets can also be configured to prevent egress from the vehicle if desired.

## CURRENT RESULTS & CONTINUING DEVELOPMENT

The Water Twister energy absorbers supplied to the New Mexico Research Institute successfully completed testing in March, 1986. It is anticipated that they will become operational at various air force bases in the near future. AAE is continuing development of complete barricade systems (engaging devices, energy absorbers, activation techniques, etc.) anticipated to meet the general requirements of different military and commercial scenarios.

Water Twister energy absorbers are already developed and tested for security barricades. AAE also has vast experience in other forms of energy absorption such as friction brakes and less expensive non-reusable techniques such as undrawn nylon. These may also be used in conjunction with security barricades as the need arises. Other system components that need to be individually specified or finalized for different scenarios are the net, stanchions, installation and activation mechanisms. Since these already exist or are envisioned as scale size versions of existing proven aircraft arresting components, the amount of development work remaining for any specific requirement is minimal. AAE will continue development to attempt to create a commercially available barricade system and would appreciate any input from potential users as to special requirements.

REFERENCE

# FIELD CIRCULAR 19-112

## August 1984

(Expires August 1987)

# USE OF BARRIERS
## (TO DENY HIGH SPEED APPROACH)
# IN COUNTERING TERRORISM SITUATIONS

**This publication reflects the current thought of this agency and conforms to current doctrine as closely as possible. It is not available through the USA Adjutant General Publication Center. This publication was prepared by the US Army Military Police School. The proponent is TRADOC.**

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## PREFACE

In recent years military installations have become the target of an ever-increasing number of terrorist attacks. These attacks have taken many forms to include vehicular bombings. Indications are that attacks on personnel and critical facilities will continue and intensify in both number and level of violence. Consequently this field circular has been established to assist the commander in assessing physical security requirements in an installation environment and to identify measures required to counter the threat.

FC 19-112 is designed to provide a catalog of barriers available to counter a high speed vehicular threat, to provide a planning methodology for commanders and others involved in security regardless of their level of expertise, and to stimulate innovative ideas as well as an attitude which considers the non-traditional threat. Appendix D includes an exercise in security planning to assist the reader in grasping the objectives of this field circular.

Successful application of this field circular will ultimately enhance the commanders ability to protect the lives and property of the US Army worldwide. The contents of this field circular will be incorporated into future editions of Terrorism Counteraction field manuals and FM 19-30. The Military Police School solicits your comments and ideas in a continuing effort to respond to the needs of the field.

Caleb J. Archer

Caleb J. Archer
Brigadier General
Commandant

TABLE OF CONTENTS

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VELOCITY AND KINETIC ENERGY FOR SEVEN VEHICLES

(by SOUTHWEST RESEARCH INSTITUTE)

| Vehicle Type | Engine (NHP) | Vehicle Mass (lb) Curb | Cargo | Test | Vehicle Acceleration Distance 500' KE ft-lb | V mph | 1000' KE ft-lb | V mph | 1500' KE ft-lb | V mph |
|---|---|---|---|---|---|---|---|---|---|---|
| Station Wagon | 130 | 3920 | 0 | 3920 | 398,000 | 55 | 594,000 | 67 | 641,000 | >70 |
| | | | 1080 | 5000 | 435,000 | 51 | 658,000 | 63 | 817,000 | 70 |
| D-150 Std Truck | 90 | 4600 | 0 | 4600 | 318,000 | 45 | 460,000 | 54 | 555,000 | 59 |
| | | | 2900 | 7500 | 372,000 | 38 | 555,000 | 47 | 682,000 | 52 |
| | 140 | 4600 | 0 | 4600 | 435,000 | 52 | 622,000 | 63 | 766,000 | 70 |
| | | | 2900 | 7500 | 514,000 | 45 | 768,000 | 55 | 949,000 | 61 |
| F-250 4x4 Truck | 115 | 8000 | 0 | 8000 | 454,000 | 41 | 678,000 | 50 | 835,000 | 56 |
| | | | 2000 | 10,000 | 486,000 | 38 | 891,000 | 47 | 912,000 | 52 |
| E-350 Super Van | 125 | 4610 | 0 | 4610 | 389,000 | 50 | 549,000 | 60 | 647,000 | 65 |
| | | | 5390 | 10,000 | 512,000 | 39 | 764,000 | 48 | 944,000 | 53 |
| | 225 | 4610 | 0 | 4610 | 576,000 | 61 | >755,000 | >70 | >755,000 | >70 |
| | | | 5390 | | 781,000 | 48 | 1,177,000 | 59 | 1,458,000 | 66 |
| 2 1/2 Ton Truck | 146 | 12,450 | 0 | 12,450 | 589,000 | 38 | 860,000 | 45 | 1,041,000 | 50 |
| | | | 11,400 | 23,850 | 727,000 | 30 | 1,084,000 | 37 | 1,347,000 | 41 |
| | 155 | 9000 | 0 | 9000 | 545,000 | 42 | 773,000 | 51 | 915,000 | 55 |
| | | | 6000 | 15,000 | 657,000 | 36 | 969,000 | 44 | 1,177,000 | 48 |
| | 360 | 9000 | 0 | 9000 | 985,000 | 57 | 1,410,000 | 68 | >1,090,000 | >70 |
| | | | 6000 | 15,000 | 1,210,000 | 49 | 1,800,000 | 60 | 2,145,000 | 66 |
| 60 Pass. School Bus | 158 | 13,000 | 0 | 13,000 | 629,000 | 38 | 915,000 | 46 | 1,104,000 | 50 |
| | | | 7000 | 20,000 | 727,000 | 33 | 1,086,000 | 40 | 1,338,000 | 45 |
| | 235 | 13,000 | 0 | 13,000 | 842,000 | 44 | 1,005,000 | 53 | 1,477,000 | 58 |
| | | | 7000 | 20,000 | 977,000 | 38 | 1,458,000 | 47 | 1,798,000 | 52 |
| 40 Pass. School Bus | 158 | 9000 | 0 | 9000 | 547,000 | 43 | 772,000 | 51 | 910,000 | 55 |
| | | | 6000 | 15,000 | 662,000 | 36 | 973,000 | 44 | 1,177,000 | 48 |
| | 235 | 9000 | 0 | 9000 | 729,000 | 49 | 1,026,000 | 58 | 1,204,000 | 63 |
| | | | 6000 | 15,000 | 886,000 | 42 | 1,304,000 | 51 | 1,584,000 | 56 |

000733

R E F E R E N C E

FINAL REPORT

# SURVEY OF CURRENT STATUS AND PLANS FOR THE INSTALLATION OF VEHICLE CRASH RESISTANT BARRIERS AT U.S. NAVY AND U.S. MARINE CORPS FACILITIES WORLDWIDE

NCEL P.O. N62583/84 M R215

November 9, 1984

MANAGEMENT GUIDANCE INSTITUTE, INC.
400 Prospect Street, Suite 130
La Jolla, California 92037

(619) 459-0422

REFERENCE

# DOD Security Requirements For Barriers

IACSE Sponsored

Government To Industry Briefing


By

T. Pickett
Naval Civil Engineering Laboratory
Port Hueneme, CA

REFERENCE

FM 5-15

FIELD MANUAL

# FIELD FORTIFICATIONS

HEADQUARTERS, DEPARTMENT OF THE ARMY

JUNE 1972

000739

FIELD MANUAL No. 5-15

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., *27 June 1972*

# FIELD FORTIFICATIONS



* This manual supersedes FM 5-15, 9 August 1968.

000740

R E F E R E N C E

* FM 5–34

FIELD MANUAL
NO. 5–34

HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, D.C., 24 September 1976

# ENGINEER FIELD DATA



* This manual supersedes FM 5–34, 12 December 1969, with all changes.

REFERENCE

SANDIA REPORT SAND84–2593 • Patent Caution • Specified External Distribution Only*

Printed November 1985

# Security Vehicle Barriers

Patrick A. Sena

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550
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000743

R E F E R E N C E

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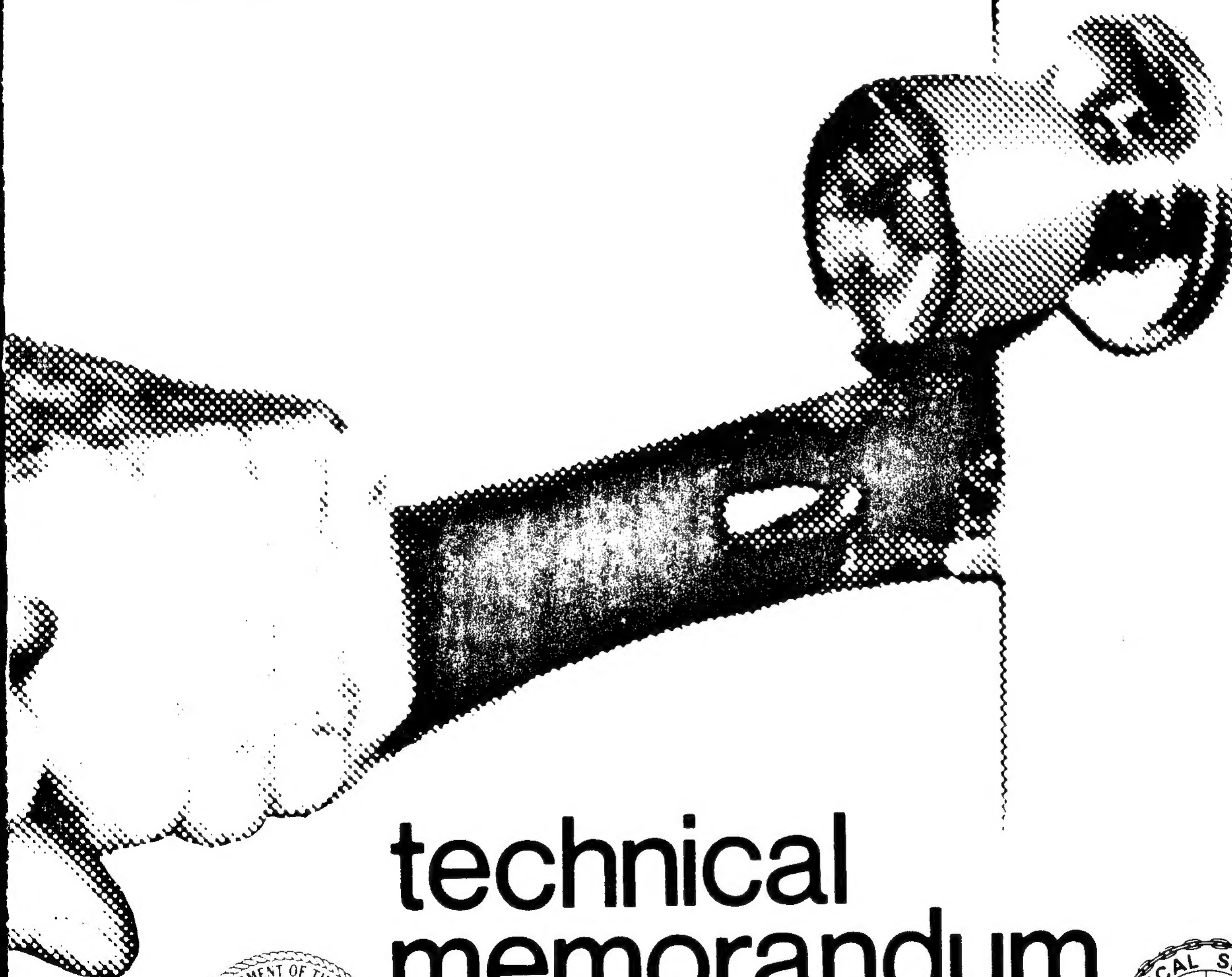
author: M. Smith

date: January 1985

sponsor: Naval Material Command and
Naval Facilities Engineering Command

program no: Y0995-01-005-314



# technical memorandum

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PORT HUENEME, CALIFORNIA 93043

DEPARTMENT OF THE NAVY NAVAL CIVIL ENGINEERING LABORATORY

PHYSICAL SECURITY PROJECT

000745